THE ENGINEER

A Seven-Day Journal

The British Iron and Steel Research Association

The eighth annual report of the council of the British Iron and Steel Research Association which was published last week, gives an interesting survey of the work carried out during 1951. The Association has also issued a pamphlet entitled *BISRA Survey*, which indicates the application and economic "slant" of the projects described in its annual report. The report clearly reflects the need for conserving scarce materials and for making the best possible use of available resources. Several of the projects mentioned in it have now reached the development and application stages. Six projects, in particular, which are now in the "pilot plant" stage are: pelletising plant for preparing otherwise intractable imported ore concentrates for the blast-furnace; plant for regenerating sulphuric acid from the residue of the waste product from the pickling plants at sheet and strip mills; automatic control of gauge in sheet and strip rolling; the continuous aluminising of steel strip and wire; the removal of sulphur from iron by the use of lime-coated coke; and the continuous casting of steel. Work on this last project is in progress at the Association's laboratories at Battersea. New melting equipment and a new casting unit with a mould 3in in diameter are in use. Billets, limited by the depth of the casting pit to 6ft in length, have been made and the use of a spring mounting for the mould has eliminated billet ruptures. A continuous casting plant is to be installed by a member firm and the Association's physics department will be kept fully informed of progress. Another matter to which the Association is giving a good deal of attention is concerned with the most efficient way of handling imported iron ore. Studies of berthing facilities and unloading equipment at sixteen of the principal overseas ports, together with studies of berthing limitations at ports in this country, have made it possible to recommend the most suitable size of ore carrier for particular trade routes. It is considered that three sizes of ships, able to carry 8000 tons, 14,000 tons and up to 20,000 tons respectively, might meet all requirements.

Deferment of Call-up of Ex-Apprentices

The Minister of Labour, Sir Walter Monckton, Q.C., has announced arrangements which are being made to permit deferment of the call-up for the Forces of a limited number of ex-apprentices engaged in certain highly skilled occupations and in certain specified rearmament projects. Deferment will be for not more than two years after completion of apprenticeship and will apply only to those men whose skill is being used to the full on the projects concerned, and provided they are not wanted in the Forces in a trade which would make full use of their skill. The specified projects are those to which the grant of "super priority"—as recorded on this page of our last issue—was recently made. There have been added, for this deferment scheme, certain naval projects such as the construction, modernisation and conversion of some aircraft carriers, frigates and submarines. The arrangements will apply to those engaged in certain skilled occupations, such as particular classes of draughtsmanship, tool making and instrument making. Generally speaking, the needs of the Forces for tradesmen from the specified occupations can be met from among men becoming due for call-up from outside the specified projects. The number of men who will be granted deferment under the scheme is not expected to be more than about 1000 a year, or about 4 per cent of the 23,000 or so ex-apprentices in engineering and metal working occupations at present being called up each year. Each application for deferment will be investigated by a technical officer of the Ministry of Labour, and where deferment is granted the cases will be reviewed about every six months to verify that the men are still being employed to the full extent of their skill on one of the specified projects.

Steel Scrap

Before the House of Commons adjourned last week for the Easter recess, there was a debate on the salvage of scrap metal, during which it was asked if all possible steps were being taken to obtain the maximum amount of iron and steel scrap in this country. In replying to points raised during the debate, the Parliamentary Secretary to the Ministry of Supply, Mr. A. R. W. Low, said that there were sixty-nine different descriptions of ferrous scrap. The scrap merchants and the steelmakers knew what could be used, how it could be used and how the materials should be collected, sorted and broken down to the required size. There was no doubt, Mr. Low continued, that the engineering industry, as a matter of course, got rid of its scrap as soon as it could, though there was some reason to believe that more could be done by industry to dispose of obsolete plant and machinery for which it had no further use. On the subject of tramway track, Mr. Low said that the total amount of steel in the tracks which were now becoming obsolete was 50,000 tons in London and about 22,000 tons in the provinces. The cost of lifting the rails was often heavy and special financial arrangements were therefore made with local authorities, where necessary, by the organisation responsible for the scrap drive. Tramline scrap was particularly good steel, and so far, Mr. Low stated, tram track for use as scrap had been secured from eleven local authorities. He added that all the nationalised industries were co-operating in the scrap drive, but said that it was important not to expect too much in the amount of scrap that could be made available from any one source. Recently, Mr. Low explained, there was a special survey of thirty collieries, which disclosed that the total quantity of scrap lying uncollected in them amounted to less than 700 tons.

Federation of British Industries

At the annual general meeting of the Federation of British Industries, which was held in London on Wednesday of last week, April 9th, Sir Archibald Forbes, the retiring president, was unanimously re-elected for a second year of office. Sir Archibald is an executive director of Spillers Ltd. and chairman of the Debenture Corporation. In the course of an address at the meeting, Sir Archibald spoke about the imposition of an excess profits levy, which, he said, was a grave blow to industrial enterprise, and competitive efficiency at a time when the encouragement of those qualities was fundamental to the strengthening of sterling and the attaining of economic stability. He felt that the enterprising and developing undertaking—notably that which had responded to the call for greater exports—would be the most severely hit. The tax, Sir Archibald asserted, would create a general feeling of disheartenment at the very time when the need was for the greatest concentration of effort; it should either be withdrawn or radically modified to remove its worst features. In addition, Sir Archibald continued, industry was faced with a major problem in the change in pattern of activity necessitated by the requirements of the defence programme and the need to maintain and increase the volume of exports of manufactured goods. It involved an increase in the export of capital goods. Whilst, in the circumstances, the inevitability of that was recognised, Sir Archibald said that he felt bound to issue a warning that its effect upon the competitive power of British industry would be grave if it led to curtailment of re-equipment in this country for more than a short time.

The Late Mr. J. E. Hodgson

We regret to have to record the death of Mr. John Edmund Hodgson, which occurred on Thursday of last week, April 10th, at his home at Bidborough, Kent. Mr. Hodgson was well known to many engineers and scientists through his activities in the old-established firm of book auctioneers in Chancery Lane, which bears his name. He was born in 1875, was educated at Tonbridge School, and began his business career with a firm of booksellers in Leicester Square. As a young man he joined the family firm in Chancery Lane, and had for long been recognised as an expert on scientific and technical literature. Among the notable collections which J. E. Hodgson made was one of early books and prints on ballooning and other forms of flight. Recently it was purchased by Sir Frederick Handley Page and presented to the Royal Aeronautical Society. Many years ago Mr. Hodgson began a study of the history of aviation, and in 1924 produced an authoritative volume entitled *History of Aeronautics in Great Britain from the Earliest Times to the Latter Half of the Nineteenth Century*. His aim was to write a chronological narrative, paying close attention to the lives and characters of the pioneers of ballooning and flight and to the technical aspects of their work. In that aim, Mr. Hodgson undoubtedly succeeded, for his book continues to occupy a prominent place in the literature of aeronautics. For a time Mr. Hodgson was honorary librarian of the Royal Aeronautical Society, and had lately become an Honorary Fellow of that Society. He was also keenly interested in the work of the Newcomen Society of Engineering and Technology, of which he became a member shortly after its formation in 1920. He served on the council of that Society for a long period, and made some valuable contributions to its *Transactions*.

The Model Railway Exhibition

The annual exhibition of models, organised by the Model Railway Club, was opened at the Central Hall, Westminster, on Tuesday last, April 15th, and will remain open until to-morrow evening. The very high standards of craftsmanship and accuracy which were set at previous exhibitions in London are well maintained this year in the many exhibits received from all parts of the country. Locomotives and rolling stock of all kinds still form a majority of the exhibits, but there are also some excellent detailed model landscape layouts with railways and stations forming the central features. Visitors to the exhibition cannot fail to appreciate the enthusiasm of a model maker when he decides to specialise in one particular aspect of railway working or equipment. It is not possible to pick out any of the many exhibits for special mention, for every one is an example of ingenuity, craftsmanship and of trouble taken in searching records for detailed information in order to provide a true replica of past or present railway equipment.

North of Scotland Hydro-Electric Schemes

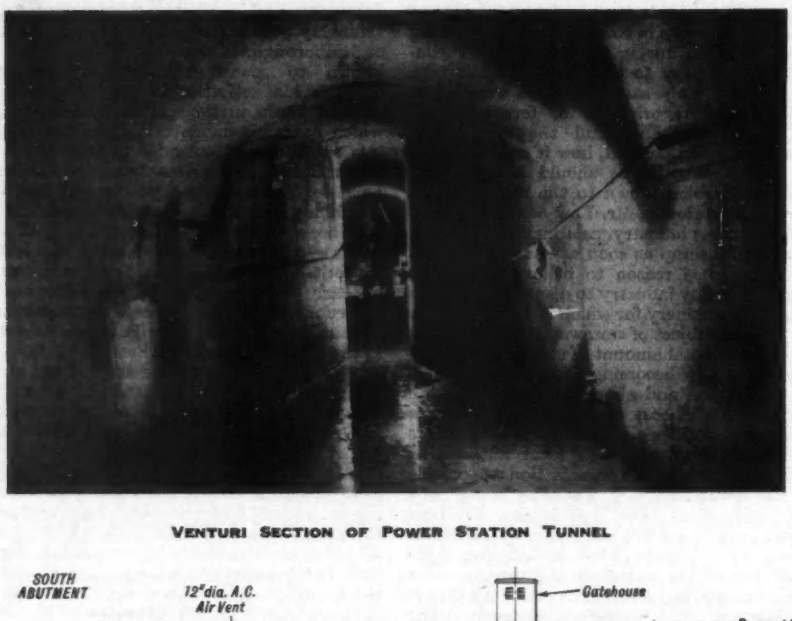
No. IV—THE MULLARDOCH–FASNAKYLE–AFFRIC PROJECT*

(*Continued from page 492, April 11th*)

The Mullardoch - Fasnakyle - Affric project is one of the larger of the North of Scotland Hydro-Electric Board's developments. The principal power station at Fasnakyle has an installed capacity of 66MW, and is supplied from a diversion tunnel, including a pressure tunnel, leading from the Benevean reservoir. There is a second and larger reservoir at Mullardoch, each reservoir being formed by a gravity dam. The estimated annual production of the scheme is 236 million kWh. Details of the Benevean reservoir, the diversion tunnels and the subsidiary power station are given hereunder.

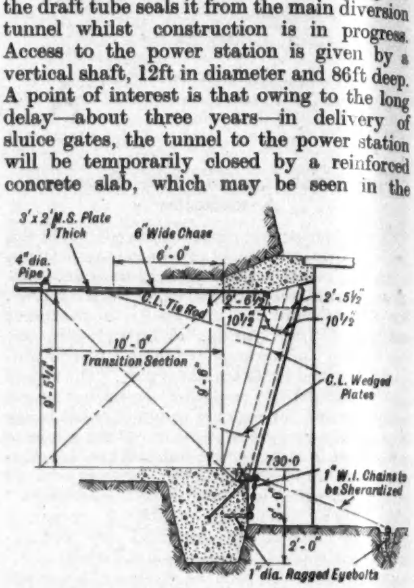
THE tunnel between the two reservoirs of the scheme is 17,214ft in length, being of horseshoe section with an equivalent diameter of 15ft 9in. It is largely unlined; a concrete invert has been laid throughout, and in places where the rock was bad a concrete lining has been added. The tunnel was driven from each end through hard psammatic and pelitic schist without intermediate access. It falls 3·26ft in level along its length; at the upstream end near Mullardoch dam, there is a coarse screen, stoplogs, guard gate and control gate. The downstream portal of the tunnel leads into the Benevean reservoir about a mile upstream of Benevean dam. A sluice gate and stoplogs are installed at the downstream end, and there is an adit for access when the tunnel is empty.

The reservoir level at Mullardoch will vary between 817 and 725 A.O.D., and at Benevean between 735 and 725 A.O.D. during normal working (the maximum draw down level will be 715), so that a small range of gross heads will be available for the small underground power station which is under construction near the Mullardoch portal. The power station intake consists of a concrete-lined tunnel with an invert level of 730, and the lowest reservoir level at which the power station will operate will be 745. The intake tunnel is 82·6 square feet in cross section, with its portal 200ft from the portal of the main diversion tunnel. The flow through both of these tunnels will be measured at venturi sections, with the necessary instruments installed in the main tunnel gate house. The venturi section of the power station intake is illustrated above.



VENTURI SECTION OF POWER STATION TUNNEL

A vertical Francis turbo-alternator set of 2400kW will be installed in the power station, and will discharge through a vertical draft tube into a tunnel which rejoins the main Mullardoch tunnel some 150ft downstream of the gate shaft. A blank flange in the draft tube seals it from the main diversion tunnel whilst construction is in progress. Access to the power station is given by a vertical shaft, 12ft in diameter and 86ft deep. A point of interest is that owing to the long delay—about three years—in delivery of sluice gates, the tunnel to the power station will be temporarily closed by a reinforced concrete slab, which may be seen in the illustration herewith. On completion of the work the intake tunnel will be flooded with a slight surcharge, and an explosive charge will be placed on the roof tie bar to fracture it. The wedges will be removed, so that on detonation the slab will pivot, like a gate, into the recess which is provided. The permanent water control gear of the power station will then become operative.

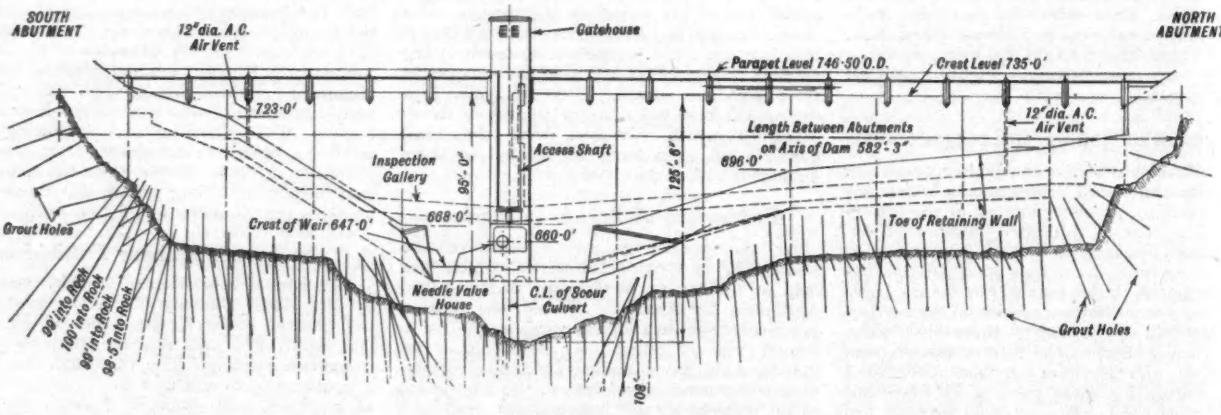


CONCRETE BULKHEAD IN POWER STATION TUNNEL

The tunnelling methods on both the main tunnels of the scheme were somewhat similar, and further details of the work are given in the section on the Benevean–Fasnakyle tunnel.

BENEVEAN DAM

The constructional details of the Benevean dam are similar in many respects to the dam at Mullardoch. The dam has a maximum height of 106ft and is 516ft long; it was built in fourteen blocks, generally 45ft long, the total concrete volume being about 54,000 cubic yards. A footbridge 8ft wide is carried on reinforced concrete piers across the top of the dam, which forms a spillway 456ft long, as shown in the sketches of the dam reproduced herewith. The photograph reproduced on page 525 shows the completed structure.



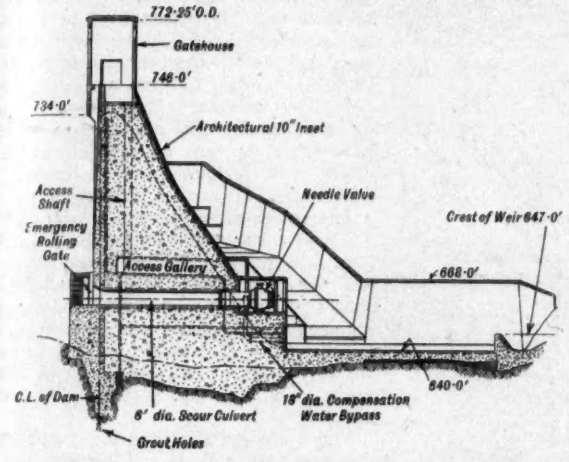
BENEVEAN DAM

The spillway has a capacity of 13,800 cusecs with a reservoir level of 739·5 A.O.D. (the crest of the spillway is at 735 A.O.D.)

* No. I, "An Introductory Survey," appeared on July 14, 1950; No. II, "The Loch Sloy Project," on July 21–August 4, 1950; No. III, "The Fannich Project," on June 8–15, 1951.

As in the case of the Mullardoch dam, the spillway design was based on tests carried out at Aberdeen University on hydraulic models.

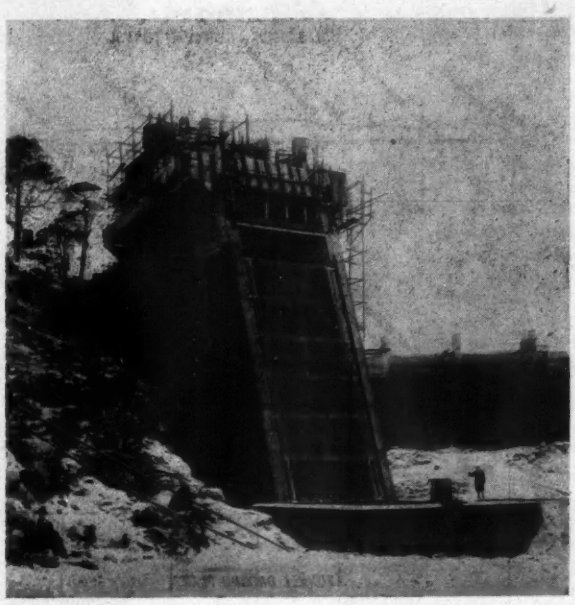
For emptying the reservoir there is a 6ft diameter scour pipe, with screen and guard gate at the upstream face and a needle valve over the stilling pool of the spillway. Various drains are provided under the spillway and stilling pool. During construction the river was first allowed to flow through a diversion channel, but later the river was diverted through three openings in the dam itself—two in one block to take the normal river flow, and a third to take flood water. Each of these openings was wedge-shaped and was concreted from the rear, when the scour culvert had been completed. An arrangement of grout tubes was provided, and grouting was carried out after the concreting, to ensure that there was no weakness in the completed structure.



SECTION THROUGH GATEHOUSE—BENEVEAN DAM

Extensive grouting was necessary to seal the bedrock of the Benevean dam, due to the presence of a zone of weathered and fractured rock. The grouting was carried out in three stages. First, holes 10ft deep were drilled at 10ft centres along the bottom of the cut-off trench, and grout was pumped into them at a pressure of 10 lb per square inch. Then, after the bottom lifts of concrete had been poured in the trench, holes up to 50ft deep were drilled at maximum intervals of 10ft, and grouted to a pressure of from 40 lb to 75 lb per square inch. In the third stage, which applied only to the southern half of the dam as required by the rock formation, after further concrete had been poured, holes 100ft deep were drilled and grouted with pressures up to 120 lb per square inch. These holes were drilled with a normal pneumatic drill, using tungsten-carbide-tipped bits, with couplings to give the length of 100ft.

The constructional plant was again somewhat similar to that at Mullardoch dam, with Bailey bridging and derricks ranged along the downstream side. Aggregate for the 4 : 1 facing concrete was obtained from a quarry opened in the glacial moraine near the power station, and aggregate for the 7 : 1 hearting was obtained from the spoil from the tunnelling. The concrete was mixed in two 1 cubic yard mixers.



CONSTRUCTION OF INTAKE STRUCTURE

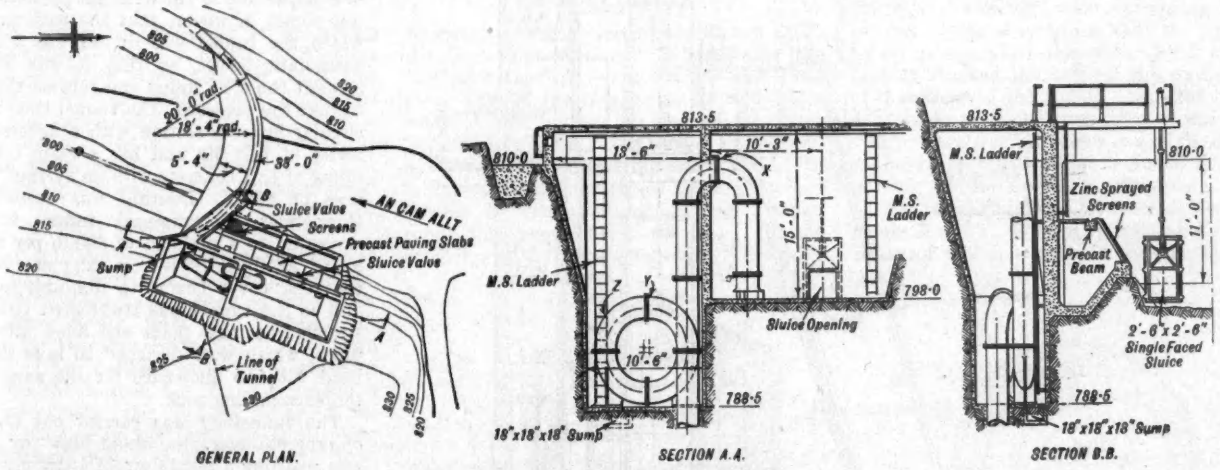
The Benevean-Fasnakyle Tunnel

Details of the tunnels of the project are shown in the illustration on page 524, from which the position of the adits and the three side stream intakes of the Benevean-Fasnakyle tunnel may be noted. This illustration has been reproduced from a previous issue* in which abstracts of the paper and discussion at the Institution of Civil Engineers concerned with this work appeared. The following description, therefore, gives only an outline of the tunnelling work enlarging on one or two points which were not covered in the previous article.

The low-pressure tunnel from Benevean reservoir to the surge shaft is 12,340ft long, being of horseshoe section, with an equivalent diameter of 14ft 6in, and having a capacity of 1850 cusecs. It is lined with 4 : 1 quality plain concrete with an average thickness of 8in. The intake structure is situated on the north bank of the Benevean reservoir, just upstream of the dam ; it is of massive reinforced concrete, being 86ft in height to the floor of the gatehouse, and about 23ft wide. It houses a coarse screen, 80ft by 21ft, a fine screen, 75ft by 20ft, a guard gate and a control gate, and is shown in two of the accompanying illustrations.

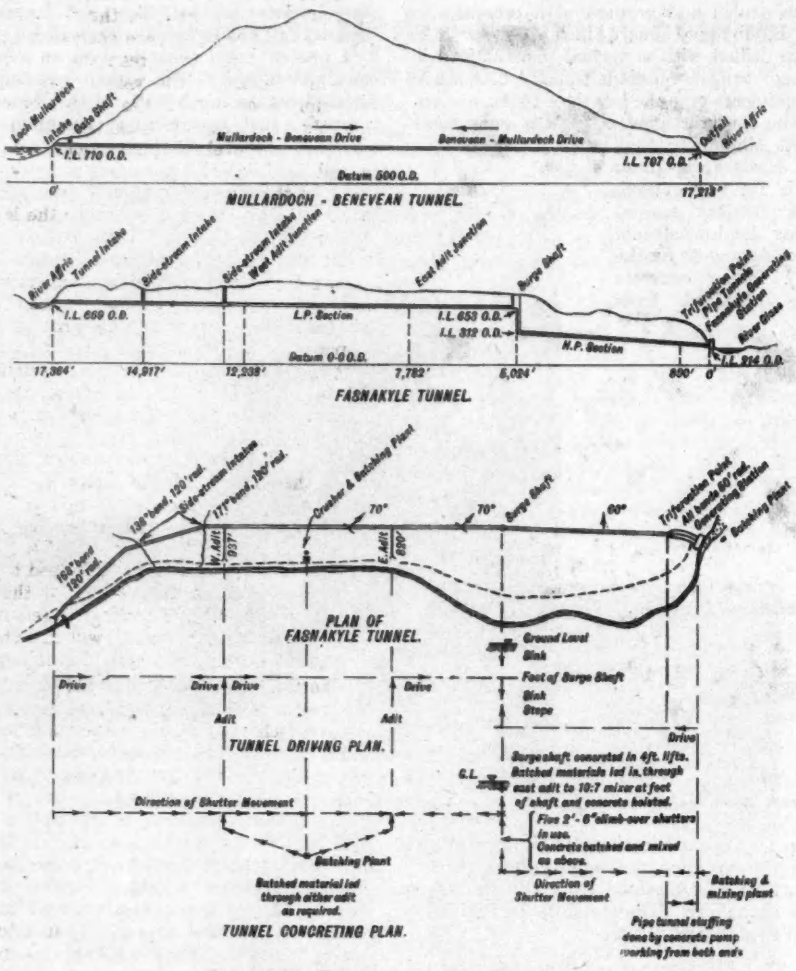
The control and guard gates are both of 12ft span and 15ft deep. The control gate is a free roller gate, working under a maximum head of 72ft. With fittings and rods, it weighs 11 tons. and has a steel plate counterbalance of 10¼ tons. It is operated by a 5 h.p. electric motor, which turns at 880 r.p.m., giving an operating speed of 4ft per minute. The out-of-balance load necessary to crack open the gate is 4¾ tons, of which the load due to roller and seal friction 4 tons. An auxiliary hand crank is provided.

The controls for this gate consist of three push buttons, marked "stop," "open," and "close," and coloured indicator lamps on a contactor panel. An amber light

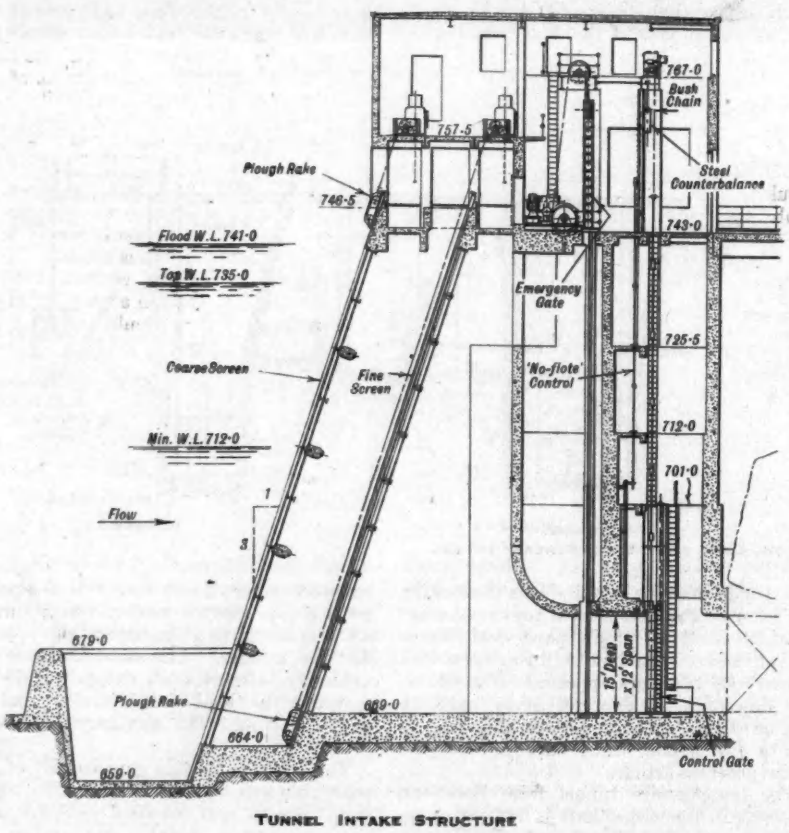


AN - CAM - ALLT SIDE - STREAM INTAKE

* The Engineer, March 10 and 17, 1950.



DIVERSION TUNNELS OF THE PROJECT



TUNNEL INTAKE STRUCTURE

indicates "tunnel full," a red light "tunnel open," and a green light "tunnel closed." Operating the "open" push button raises the gate 12in above the sill, when the "crack open" switch stops it; it remains in this position until the tunnel fills and the water level reaches the "No-flote" electrodes. Then the amber light indicates "tunnel full," and the "open" push button is again pressed to raise the gate to the fully-open position, which is indicated by the red light. The gate may also be operated by remote control from Fasnakyle generating station.

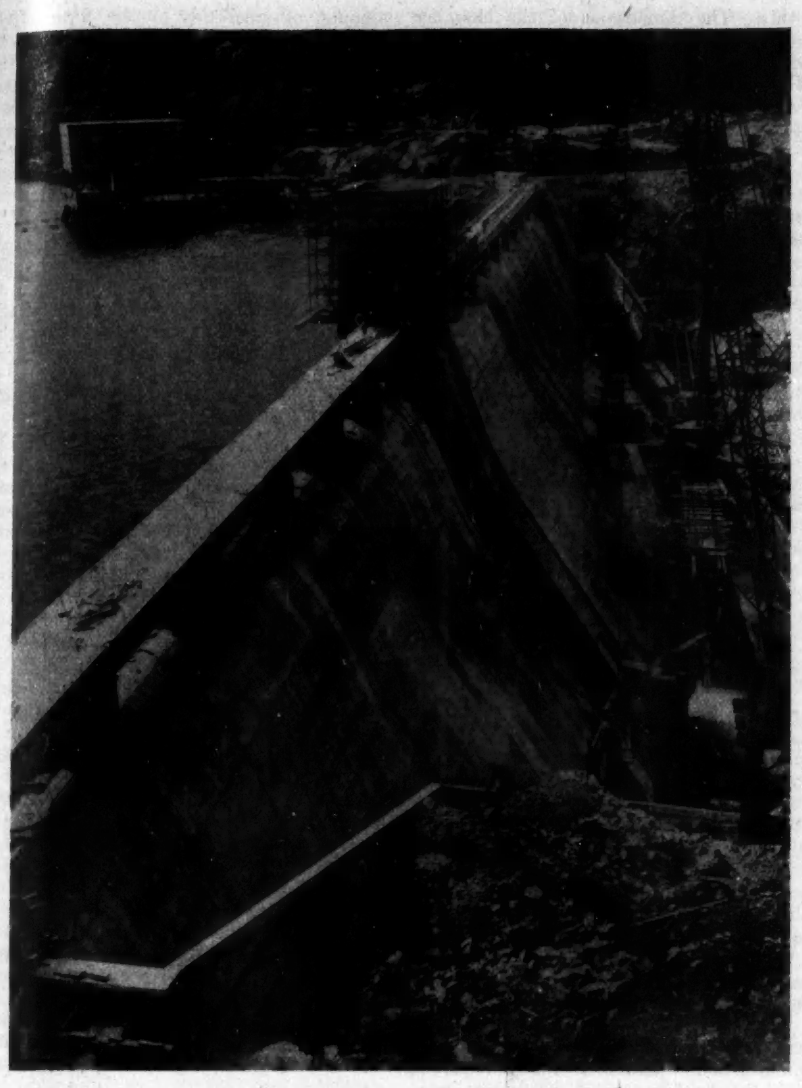
The guard gate, or emergency gate, as it is sometimes called, is also a free rolling gate, and weighs 21 tons. Its top water load is 23 tons, with a friction load of 4·5 tons. A load of 48·5 tons is necessary to crack open the gate through gearing and a 20 h.p. 730 r.p.m. motor, to give a hoisting speed of 4ft per minute. The lowering speed, by gravity, is 12ft per minute, which is controlled by an automatic centrifugal brake, and a hand-operated brake. The gate controls are at the operating gear.

The coarse screen covers a width of 20ft 6in, and consists of 4½in by ⅜in thick bars, with 5½in spaces. The fine screen spans 19ft, and has 3½in by ½in thick bars, and 2½in spaces. A plough rake is provided for cleaning each of the screens, the rakes being electrically-operated, each by an 8 h.p. motor, turning at 710 r.p.m., and lifting at 10ft per minute, and lowering, by gravity, at 20ft per minute.

The surge shaft is 150ft deep and 45ft in diameter. Immediately below it is the vertical shaft, 341ft deep and 14·5ft in diameter, leading to the pressure tunnel. The surge shaft excavation was enlarged from a pilot shaft. The lining of the pressure shaft was placed with six lifts of steel shuttering, the bottom lift being removed to the top for each operation, and the surge shaft with timber shutters in 4ft lifts.

The pressure tunnel was originally designed with a steel lining. A disadvantage of this design, however, is that if a hydrostatic head is built up outside the tunnel and the tunnel is dewatered there is some danger of collapse due to the external pressure. It was found, however, that the rock through which the tunnel was driven was a sound psammatic schist, so that it was decided to omit the steel lining and rely on the rock to take the pressure. The tunnel therefore is circular in cross section with a finished diameter of 14ft 6in and has a plain concrete lining of 4 : 1 concrete with an average thickness of 20in. Grouting was carried out throughout the pressure tunnel in two stages up to a pressure of 300 lb per square inch. At about 700ft from the power station the rock cover begins to diminish rapidly, and so the tunnel was trifurcated 100ft upstream from that point and lined with steel pipes, which were designed to take the full head with no allowance for the support of the surrounding rock.

The tunnelling was carried out at rates of progress averaging about 88ft per week, and reaching a maximum of 132ft per week. Drilling and mucking was done with a drilling carriage and "Eimco" loaders. In the later stages of the work, mainly for the Mullardoch tunnel intake and for drilling the grout holes in the Fasnakyle pressure tunnel, tungsten-carbide-tipped drilling tools became available and were introduced. A pneumatic concrete placer of American design was used extensively in emplacing the lining; concrete pumps were also employed. The pneumatic placer, which has a capacity of 1 cubic yard, shoots the concrete, by compressed air, through a pipe



BENEVEAN DAM AND TUNNEL INTAKE

placed inside the shuttering in the crown of the tunnel. Rates of placing of 30 cubic yards per hour were achieved with this machine, the advantages and drawbacks of which were discussed in the reference given earlier. The rates of progress of the tunnel lining reached a maximum of 425ft per week, and averaged about 252ft per week.

Side-Stream Intakes

Two side-stream intakes which lead into the main tunnel are of original design, their final form having been evolved after extensive model tests by Professor J. Allen at Aberdeen University. The main object of the design was to avoid injecting air into the tunnel, and for this reason a siphonic intake was adopted to avoid the intake running on part load by substituting intermittent discharge at full bore. However, little reliable data were available on which to base the design. Two of these siphon intakes were required, one of 12in and one of 21in bore.

A cross section of the An-Cam-Allt intake is shown in the illustration on page 523. Since some air must necessarily be entrained during priming it was considered desirable to obtain rapid priming at as low a discharge as possible, and to extend the intervals of time between each one as much as possible by using the total capacity of the forebay.

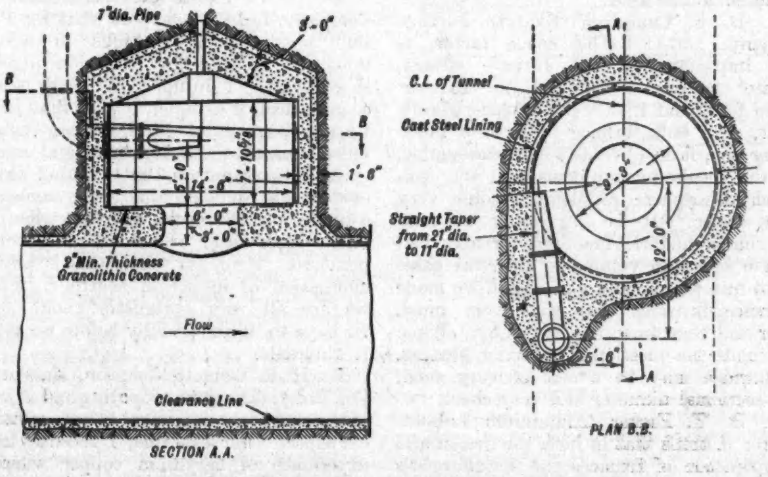
Assuming that the water was rising in the forebay, water would eventually begin to discharge over the crest of the siphon at *X*, the flow increasing and falling down the vertical leg leading to the circular trap. The lower limb of the trap would fill and water would discharge over the crest of the upper limb of the trap at *Y*, the level in the vertical leg being a little higher than that at *Y*. In falling down the vertical leg the water would entrain a certain amount of air bubbles round the lower limb of the trap. On the discharge of the system becoming sufficiently great to result in a flow exceeding approximately 1ft per second in the full pipe, air bubbles would begin to be carried round the lower limb of the trap, resulting in a reduction in pressure in the vertical leg between the siphon crest and the trap and consequently an increase in discharge at *X* as well as a rise of level in the vertical leg. This would be followed by a more rapid entrainment of the air in the leg and rapid priming of that part of the system above the level of the trap.

Simultaneously entrainment of air would take place in the vertical leg leading to the nozzle, which would be accelerated by the increased discharge due to the priming of the upper part of the system. The trap is, in fact, intended to effect an early priming of the whole. It is true, of course, that the removal of air from the upper vertical leg would only be done at the expense of increasing the air pressure in the lower leg, but since the volume of the latter is so much greater, the pressure here would rise more slowly than that in the upper leg would diminish.

The vortex chamber was designed to dissipate the energy of the jet and, at the same time, act as a sort of centrifuge to remove the greater part of the air which will pass through the nozzle during priming and breaking.

The final result of the model experiments indicated that the fundamental assumptions upon which the siphon intakes were designed were correct. The results obtained from the experiments, however, necessitated some changes from the preliminary design. The length of the intake leg of the siphon below the throat was increased, so that full use of the pondage provided by the forebay was made use of. This requires the siphon to come into operation at much greater intervals and thus the total amount of air entrained, during priming and breaking, is not so reduced.

The experiments upon priming indicated that the initial assumption, of the air in the upper leg being entrained and carried around the trap when the velocity in the trap was in the order of 1ft per second, was correct. There was, however, some element of doubt thrown on the assumption that the siphons would prime when the water level in the forebay reached the level of the centre line of the throat of the siphon. This led to the decision to raise the crest level of the main weir to 6in above the centre line of the throat of the siphon. If it should be found that the priming of the siphon is incomplete, then a ¼in tube could be connected between points *X* and *Z*, with an air vent at *Y*. The action of the siphon would then be that as



VORTEX CHAMBER BELOW AN-CAM-ALLT INTAKE

water rises in the first leg air is displaced and evacuated via *X*, *Z* and *Y*. When the water covers the hole *Z*, the ¼in pipe *XZ* is sealed, but by this time an appreciable flow will be taking place over the throat of the siphon. A small subsequent increase in discharge, which will not be accompanied by a large compression effect, will result in a velocity sufficient to carry air bubbles round the trap from the second leg to the third leg, whence they could escape via vent *Y* (the pressure in the third leg remaining atmospheric). This transference of air from the second leg will result in the priming of the upper siphon and hence of the whole system.

The experiments on the vortex chamber were very interesting, and led to some alterations to the preliminary designs. The vortex chambers are now positioned above the tunnel, so that the exit passages are in the bottom of the chamber, as the performance of the model was greatly improved by this. The dimensions of the chamber for the 12in siphon were unaltered, but the diameter of the chamber for the 21in siphon was increased to 13ft. 6in, the other dimensions being unaltered. The nozzles in the vortex chamber were positioned near the top of the side of the chamber. The discharging capacities of the new siphons are shown in the table, these figures being measured on the models and a scale correction applied. They agreed with the calculated figures within allowable limits.

	Head, feet	Mean discharge, cusecs	
		I	II
21in	113	53·8	53·0
12in	80	16·0	14·0

I: air vent closed after priming.
II: air vent left open after priming.

Our illustrations show the final design for the An-Cam-Allt intake based on the above tests. The intake of the siphon is at a level of 798·75, the centre line of the throat at 809·5, with the crest of the weir 6in higher. The radius of the trap is 3ft. 6in.

(To be continued)

The Institute of Metals

No. III—*(Continued from page 495, April 11th)*

THE discussion of the symposium of papers on equipment for thermal treatment was resumed at 2.30 p.m., on Wednesday, March 26th.

Mr. J. O. Hitchcock (Henry Wiggin and Co., Ltd.): An examination of costs on a number of electric furnaces of different kinds, including batch, belt conveyor pusher tray and continuous pull-through types, has revealed some interesting information. The cost of operating electric batch furnaces where the charge and time can vary can easily be doubled by incorrect operation. Belt furnaces, provided they are regularly fed, are less prone to misuse, so that while it might be expected that a lower annealing cost could be achieved on a batch furnace because there is no belt to heat up and no belt replacement cost, actual figures on one installation where both furnaces are installed on similar work showed that over a period of some months lower costs were achieved by the belt furnace. A pull-through strip annealing furnace showed even lower relative annealing costs. One can cut costs on the particular products with which I am concerned by one-half, and that is the responsibility of the metal user rather than the furnace designer. We buy these beautiful furnaces, but we do not always use them as they should be used.

Mr. D. F. Campbell (Electric Furnace Company, Ltd.): The space factor is very important in all furnace design, because factories cost up to £3 per square foot, and if one can replace a 40ft, a 50ft, or a 60ft furnace by a very much shorter one, it is obviously more economic, and the insulation problems and the controlled atmosphere problems become very much easier. It is interesting to note that the prehistoric fuel-fired furnaces had to have a certain volume to burn the gases and to mix the air and gas. Then we made resistance furnaces that were very much flatter and very much less in volume. When we come to the question of induction heating, the furnace may be a slot of very small cross-sectional diameter and very short.

Dr. R. T. Parker (Aluminium Laboratories): I think that in both the design and the operation of furnaces the metallurgist's point of view should be remembered. We heard Mr. Campbell talking about the use of induction heating for preheating billets. I think that is an extreme case where the metallurgist's opinion should be taken care of before the process is put into operation. In the past, because of limitations of heating equipment, billets have been heated relatively slowly. If we now proceed to a very much faster rate of heating we may finish up with a structure which is not quite so amenable to, perhaps, extrusion forging, and so on. I think that the same principle applies possibly to some of our other methods of heating metals for working, whether it is for annealing or for final treatments. For example, I should like to hear from Monsieur Lamourdedieu whether in his process, in which the heat-treatment times are relatively short, he is completely satisfied that in that short period there is complete solution of the alloying constituents.

Mr. Stanford (Aluminium Laboratories): I was particularly interested in the paper by Monsieur Lamourdedieu, in which the method of induction heating is described, and I anxiously await the results of the use of the equipment on an industrial scale, mainly because, in the early part of the war, I studied this particular method of heating and I came to the conclusion that it was not a satisfactory proposition.

Mr. C. P. Paton (Northern Aluminium Company, Ltd.): I support what Dr. Parker said about being cautious in adopting induction heating for extrusion ingots or sheet ingots. I do not think there is as yet a great deal of experience with that process. I know that a number of these new induction billet heaters are being built and are now going into operation, but I think there is evidence to indicate that with some alloys a poorer surface results after extrusion if the ingots have been brought rapidly to temperature. I do not think this is any condemnation of induction heating; I think we are all very optimistic about it, but we have to think carefully before we attempt it wholesale.

Mr. H. E. Bennett (Johnson, Matthey and Co., Ltd.): The rates of heating and of cooling of the charge are important from a metallurgical aspect. For example, I recently had an experience of beryllium copper where the charge was put into a furnace with a large amount of steelwork in the form of jigs holding the parts to be annealed, and the temperature was of necessity raised very slowly. This resulted really in precipitation hardening taking place at too low a temperature. We are at present doing a little research to find out exactly the effect of this, but we believe that it results in discontinuous precipitation which gives rise to undesirable brittleness in the alloy afterwards.

It is a point to bear in mind that the speed of heating some of these alloys to the required temperature is very important from the point of view of preventing precipitation from taking place at too low a temperature. The same thing applies, as one contributor mentioned this morning, at the other end of the scale—the speed at which the metal cools down afterwards. In annealing a standard silver, for instance, if we cool it too slowly, we tend to get precipitation and this gives hardening, which is undesirable. Therefore, these two factors must be borne in mind in considering the particular materials that are being heat-treated.

Another point that I should like to mention is the evenness of temperature that we get in our furnaces. I suppose that very often we are not at all sure of the evenness of the temperature, particularly in the lower temperature ranges. Very often we find it expedient, for practical reasons, to put a thermo-couple perhaps just at the top. I am thinking now of a bell furnace where a large spider is lowered into the bell and the thermo-couple is placed for convenience of loading and to prevent damage, at the top part of the furnace. In a job which needed a control within 20 deg., at any rate, some tests showed that we were not getting that degree of evenness over the furnace. By putting elaborate thermo-couple systems in, we found that the temperature variations throughout the mass were very considerable. I know that there are difficulties there, but the furnace makers ought to bear in mind this matter of the evenness of temperature and the methods of recording the temperatures that are obtained.

Mr. Barfield (Wild-Barfield Electric Furnaces, Ltd.): On the question of induction heating, there have been a good many arguments for and against the rapid heating. I am very much interested in this process, and I think that there is a great need for it to be tried. At the moment there seems to be some reluctance to introduce it in British industry, but it has been introduced in America. Surely none of the points that have been argued can really be settled until the thing has been tried out. I feel that hesitation in this matter may be carried too far.

Mr. Howard (Electric Furnace Company, Ltd.): Bright annealing and bright heat-treatment have come to stay, and we are familiar with the problem of maintaining a suitable and correct atmosphere, particularly where we have to have a muffle which is operated at furnace temperature. One of the advantages of induction heating is that one can keep the muffle on the outside of the inductors and so make the muffle problem—or shall I call it the container problem, for holding gas—simpler than for anything that has to operate at temperatures. It is possible to have gaskets and spy holes and covers that can be removed, so that one can see the job. It also enables us to thread the strip through the inductors and through the cooling chamber, because (as I have said) it is possible to have fairly easily removable covers and rubber gaskets which are perfectly airtight. There is, of course, one very important problem. We can heat up very quickly indeed. Of course, we must heat

quickly only such materials as can be heated quickly without detriment from a metallurgical point of view. There are plenty of metals and alloys that can be done in this way. Aluminium and its alloys—and especially its alloys—probably cannot be heated as quickly as some of the others, but with many of the other non-ferrous alloys I think there is not the same limitation to the speed of heating as there is with the aluminium alloys. But in order to be able to take full advantage of this speed of heating, we must also be able to cool sufficiently rapidly. I am assuming, in making that remark, that there are not any insoluble problems from a metallurgical point of view in the rapid cooling. Ideas and developments that are now coming forward do give us real promise that the cooling, where permissible, can be done also at a reasonable pace.

Dr. E. Voce (Copper Development Association): For copper alloy extrusion purposes, billet heating by induction methods seems to be attractive, but it certainly would be too rapid in some cases to ensure homogeneity of structure. One knows that one of the main alloys for extrusion is 60/40 brass, and I think it is important in an alloy such as that to heat it thoroughly through, because it is an alpha-plus-beta structure and one wants to get it into a more or less equilibrium state before extruding. Certain alloys of copper are pretty difficult to get into a homogeneous condition, such, for instance, as cupro-nickels. The cored structure seems to persist for a long time in them, and I do not think that rapid heating would be very satisfactory.

I feel that the auxiliary equipment in furnaces is also important. In the paper by Davis and Temple, the last paragraph states: "For the solution heat-treatment of temper-hardening alloys, batch furnaces are generally used, and some provision for rapidly withdrawing the charge from the furnace and lowering it into water is essential." I wonder whether any furnace maker present could give a little more information about the sort of equipment that is normally installed for quenching these heat-treatable materials. I have no doubt that in the aluminium industry they are very widely used. It is necessary to use fairly rapid quenching methods. Relatively few of the copper-based alloys require that rapidity of quenching, but some of them do, and I am not at all sure what kind of equipment to recommend for that purpose.

Mr. C. J. Evans (The General Electric Company, Ltd.): Mr. Fowler raised a very important point this morning in regard to the cost of the ancillary gear on a furnace. The tendency nowadays is to go in for continuous furnaces as much as possible, and I personally agree with that. But if we have a long furnace, we must have a fairly considerable amount of coiling gear to enable us to maintain these big outputs of 2, 3 or 10 tons per hour. Assuming that a furnace costs £60,000 or £70,000 with coiling gear, of which the coiling gear possibly costs £30,000 or £40,000, who is going to stand the risk of installing equipment like that? It is absolutely essential to have an installation that will work. The suggestion has been made that a panel should be formed to discuss this and sundry other problems between the furnace makers and the furnace users. I would say that the solutions to problems of that sort is for the furnace makers and the furnace users to get together with the rolling mill people, so that they can get down to the job between them and work it out to a certain extent on a financial basis. On the one hand, there is the buyer who says that a certain piece of equipment is very expensive and it must work. On the other hand, there are the furnace makers who say that they agree that the equipment is expensive, but that they have to take every precaution possible to make sure that it will work. The attitude of the rolling mill people will be the same. If, as is suggested, they could all get together and tackle the job in the simplest form on a commercial basis, I am convinced that we should have continuous furnaces in this country doing copper, brass and various other metals, such as aluminium, as successfully as in the U.S.A.

Mr. Ashton (Frederick Smith, Ltd.): I should like to refer to a method of heating which I think has not been mentioned at all, namely, heating by passing a current through the metal to be annealed by ordinary circuit methods—that is, apart from induction methods. In any furnace operation one is heating up, besides the metal one is interested in, a very high proportion of structural material. The beauty of generating heat within the metal itself is that those increments of power consumption are completely eliminated. The heat is generated where one wants it and nowhere else. I have seen copper (which, of course, is the worst possible material to tackle from this point of view) heated up to annealing temperatures in seconds by the use of quite heavy currents fed into it by contacts. I have seen fine copper wires annealed continuously by running over contact pulleys with a potential across them at speeds of thousands of feet a minute, and this has been quite satisfactory. My own view is that the furnace methods of heating, at any rate in connection with some copper products—not all—are at the top of the slippery slope which leads to obsolescence. I am not saying that they are going to be obsolescent the day after to-morrow, or next year, but I think the tendency has started and I am sure that it will go on.

Dr. E. Voce (Copper Development Association): So much has been said both this morning and this afternoon about the cost of cooling, the space required for cooling and the general inconvenience of cooling that it occurs to me that it might be almost economical in some cases to introduce refrigeration. Has that ever occurred to any furnace manufacturer? Is it possible?

Mr. G. A. Oxby (Telegraph Construction and Maintenance Company): In connection with continuous annealing furnaces, one point occurs to me which has not been mentioned hitherto by any speakers, and that is the possibility of measuring continuously some physical property of the product as it is passing out of the furnace or out of the heat-treatment equipment. For example, the continuous measurement of the resistivity or even, in some cases, the possibility of the measurement of the magnetic properties, or something of that kind, might be a very useful help as a control of the quality of material passing from the furnace. That would be a much less expensive business than the sampling of pieces from the coils.

(To be continued)

Hydrogen Cooling of Large Turbo-Generator Windings

An interesting hydrogen cooling method, which has been developed by the Westinghouse Electric Corporation, of East Pittsburgh, Pennsylvania, is expected to permit an increase of as much as 50 per cent in the output capacity of large turbo-generators. This new method of hydrogen ventilation is based on the internal cooling of the conductors by making them hollow and blowing the hydrogen gas at high velocities through the ducts, thus placing the coolant in more intimate contact with the material in which the heat is generated. The method has already been tested on large-size models.

BECAUSE of the existing labour and materials costs, and the desire to keep electric power costs low, it is becoming increasingly necessary for electric power companies in America to install the largest generating units which can be utilised effectively by their individual systems and the systems with which they are interconnected. Several grid systems in the United States are of sufficient size and closely enough integrated by interconnection with other similar systems to justify generating units having a capacity in excess of 200MW. Plans exist for cross-compound steam turbine generating units to be built for ratings of up to 300MW at 3600 r.p.m., or a combination of 1800 and 3600 r.p.m. It is believed that such generators could deliver this output rating at power factors of 0·8 to 0·85, when using hydrogen gas pressures of 30 lb per square inch gauge. Since the tandem-compound turbo-generator unit has fewer bearings, a higher output efficiency, lower capital and operating costs, and requires less power station space, it has been considered desirable to develop it for larger ratings. Although tandem-connected generators can now also be built for ratings of up to 300MW, it is felt that such a unit would probably represent little savings or advantages over a cross-compound machine, and, consequently, would not normally be preferred. On the basis of available materials, present American design practices, generator characteristics, and conventional construction, it is possible to build single-unit generators having a maximum rating of about 200MW, a power factor of 0·85, and a hydrogen pressure of 30 lb per square inch gauge. The rotors of the units for these large ratings would operate above the first and probably above the second critical speed. At 0·9 power factor the maximum generator rating could be increased to 230MW.

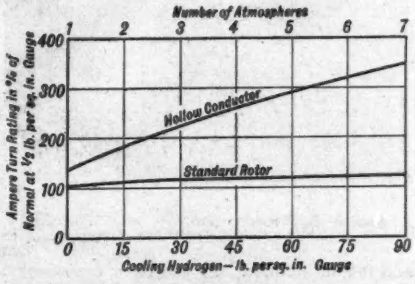


FIG. 1—EFFECT OF HYDROGEN PRESSURE ON AMPERE TURN RATING

During recent years, much attention has been given to possibilities of using improved cooling media as a means of overcoming the capacity limitation of large turbo-generator units. The answer to a substantial improvement is now believed to lie in the internal

cooling of rotor and stator windings with high-density hydrogen. This method has been found to offer possibilities of greatly increasing the amount of copper losses which can be dissipated for a given maximum temperature rise. By eliminating most of the heat flow through the insulation of the windings, the temperature of the windings is determined by the temperature of the hydrogen gas in contact with the copper, and the heat transfer coefficient from the copper to the gas. The curves in Fig. 1 show the rotor ampere conductor rating obtainable from tests on a full-size stationary model, with the average and maximum copper temperature maintained constant for both methods of construction. The lower curve is for the conventional rotor design with external cooling, and shows that further increase in hydrogen pressure will offer very little increase of rotor ampere conductors. On the other hand, it is shown that considerable benefit may be gained by the use of hollow conductors, particularly at high cooling gas pressures.

The increase in ampere conductor output for the internally-cooled rotor winding is obtained by passing large masses of hydrogen gas through internal passages of the conductors at relatively high velocities. It is, therefore, obvious that the full advantage of such cooling is associated with high hydrogen pressures and requires the use of high-pressure blowers to circulate the gas through the internal ducts. A sectional view of a rotor and rotor winding (Fig. 2), shows the path of the hydrogen gas flowing through the rotor conductors for a particular rotor design. The rotor winding insulation problems are considered to be fundamentally the same as those encountered in conventional construction. Creepage paths of the conductors at the central discharge sections are of the same magnitude as for the end turns of present machines. Although the tapered rotor slot may prove to be more difficult to machine, its use is claimed to result in a much simpler blocking for the straight portion of the rotor coil ends. The end turn blocking is further simplified by the elimination of gas flow between coil sides and the use of a constant cross section of copper for the circumferential portion of the rotor end turns. In this design of rotor the conductors are necessarily of large cross section

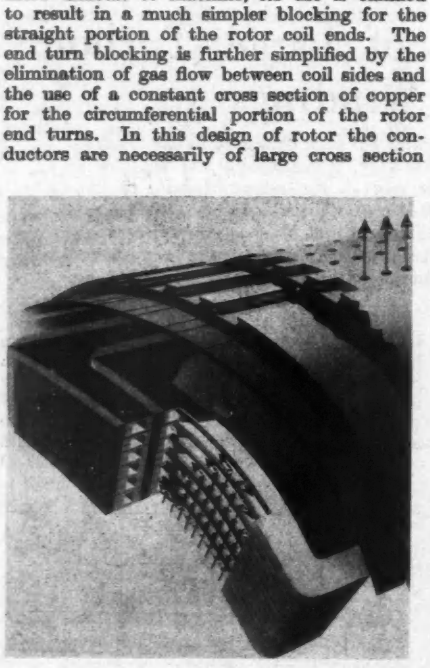


FIG. 2—SECTIONED ROTOR AND HOLLOW COIL WINDING

and few in number. As the rotor ampere conductors are greatly increased by the application of internal cooling, the field current is large, the field voltage relatively low, and the excitation input approximately twice that for a rotor of a generator of conventional design. Rotating coil models of large size have been built and tested to demonstrate that internal blowers mounted on the ends of the rotor can deliver the required mass of hydrogen through the rotor conductors.

Benefits similar to those outlined above are believed to be obtainable also from internally cooling the stator coils. The insulation problem is more difficult for stator coils because of the higher voltage involved and the need for creepage paths considerably longer than those required for the rotor. With machines in which the cooling can be accomplished by passing the hydrogen gas through the full length of the coils, the creepage problems are relatively simple and no difficult mechanical

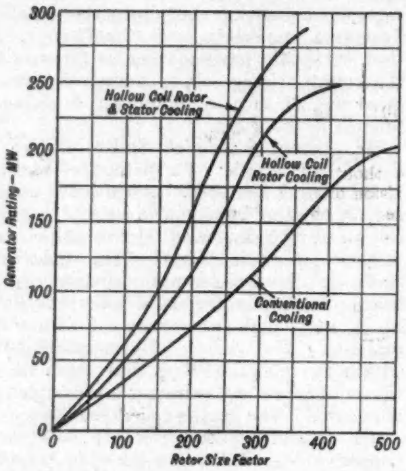


FIG. 3—EFFECT OF HOLLOW COIL COOLING ON ROTOR SIZE

and ventilation problems are involved. In the longer machines, in which a central hydrogen discharge is required, the creepage problems are more difficult, but do not appear to be insurmountable. At present, the development of the internally-cooled stator coil has not been carried to the same stage as that of the rotor coil.

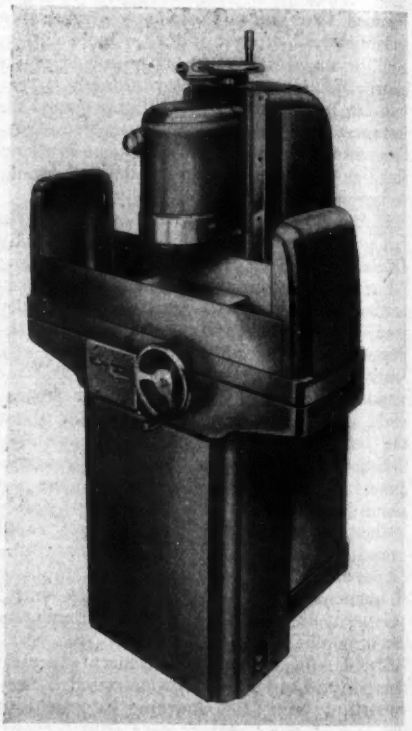
The curves of Fig. 3 show what can be expected of internally-cooled windings as compared with conventional designs. The ratings in megawatt are based on a power factor of 0·85, a short circuit ratio of 0·8, and operation at a hydrogen pressure of 30 lb per square inch gauge. From a magnetic standpoint, no changes have been made in the flux densities in the stator and rotor portions of the magnetic circuit. In comparing the physical dimensions of a 200MW unit for the two methods of design, the size factor for the rotor with inner cooling of the conductors is only 62 per cent of that for the conventional rotor. The reduction in stator dimensions is of smaller magnitude since internal cooling of the stator conductors is not used. In the case of internal cooling for both stator and rotor windings, the rotor size factor is only 50 per cent of that for the conventional machine of the same rating and performance characteristics; a similar reduction in the size factor for the stator would also be obtained.

Two 3600 r.p.m. generators, rated, respectively, at 175MW and 200MW are to be made by the Westinghouse Electric Corporation, to be completed by 1954, and a 90MW, 3600 r.p.m. machine using internal cooling for both the stator and rotor windings is expected to be available for testing later this year. The company feels that the development of internal cooling with high-pressure hydrogen gas opens up a new era in the design and construction of turbo-generators without involving too great a departure from present practice and experience. The increased output per unit of generator weight makes possible smaller sets for a given rating and appreciably larger maximum ratings at a speed of 3600 r.p.m. than those obtainable with conventional designs. The overall efficiency, including generator bearing losses, is expected to be essentially the same as for present conventional units. The increase in copper losses of the stator and rotor windings due to higher current densities is expected to be more than offset by the reduction in bearing losses resulting from the smaller bearings required for the smaller rotors, and the reduction in rotor surface losses resulting from the appreciable increase in the radial length of the air gap and the decrease in rotor surface area. The increase in ventilation loss due to higher fan pressures would be partially offset by the reduction in the volume of gas to be delivered by the blowers. For turbo-generators with internal cooling of the conductors the excitation and terminal voltages are lower than those employed for conventional machines of similar capacity, because of the mechanical requirement for larger overall section for the rotor conductors, and the inherent limitations in insulation surface creepage at the inlet and discharge sections of the conductors for both windings.

A Vertical Surface Grinding Machine

THE vertical surface grinding machine illustrated below is a new product of Bourdon Tools, Ltd., of Union Road, Croydon, Surrey, and is designed for precision tool-room or production shop work. This machine has a 42½in by 11in table, which accommodates work 18in long, 6in wide and up to 10½in high under the grinding wheel.

The wheel-head of the machine can be tilted up to 2 deg. on either side of the zero position for cross grinding or producing slightly concave surfaces. It is counter-balanced and is carried on long, square-jibbed



SURFACE GRINDING MACHINE

sides adequately protected against grinding dust. A fine vertical feed dial, reading in increments of 0·00025, is fitted in a convenient operating position on the head, and quick wheel adjustments can be made through a coarse feed gear.

The hardened and ground alloy steel grinding wheel spindle is driven through vee belts by a 2 h.p., 2800 r.p.m. continuously rated motor, and it takes a wheel 6in dia. by 5in bore by 2½in. Coolant is supplied from a large double compartment tank by a submerged centrifugal pump driven by a ½ h.p. motor.

INSTITUTION OF WORKS MANAGERS.—The Institution of Works Managers states that its final examinations for students will take place on Tuesday, May 20th. All who intend to take the examinations are asked to communicate with the General Secretary of the Institution at 67–68, Chandos Place, London, W.C.2.

A Transfer Machine for Gearboxes

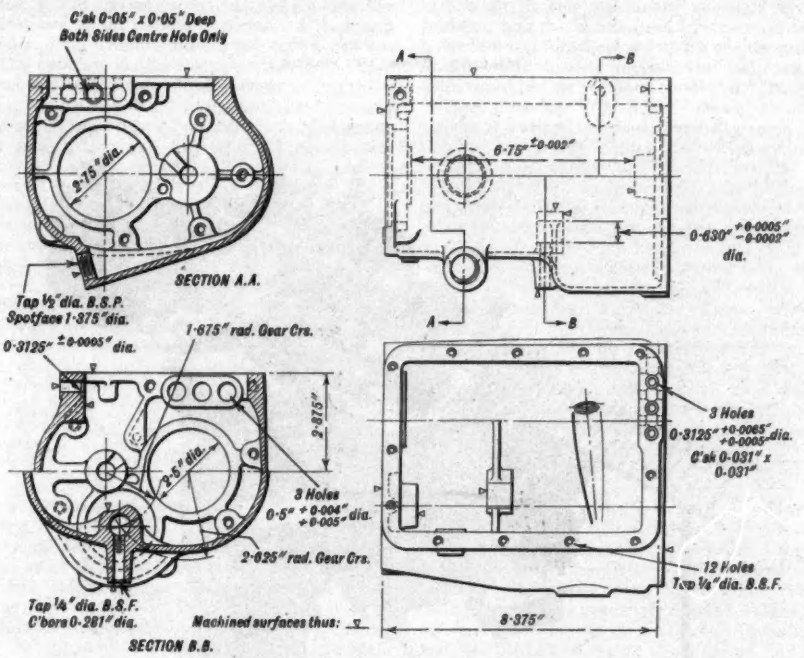
A new transfer machine, which has been installed at the works of Morris Motors, Ltd., has replaced eighteen other machines, and in eighty seconds completes all the drilling, reaming, tapping, and internal milling operations on a gearbox casting. The machine has twenty-eight machining stations, and automatic gauging equipment fitted at two points in the production line checks that the preceding operations have been completed to a consistent degree of accuracy.

MULTIPLE station transfer machines in which a sequence of machining operations is carried out on a single component have been used for some years in the American motor-car industry, and their use is increasing in this country. In plants where the number of components required justifies the considerable financial outlay entailed, such a machine has many advantages over the use of a group of machines tooled up to perform successive individual operations. One of the most recent machines of this type to be placed in service in this country is at the Coventry works of Morris Motors, Ltd., and its arrangement can be seen in the accompanying illustration. This transfer machine is used in the production of gearboxes and it was designed and built by James Archdale and Co., Ltd., of Worcester, in consultation with the Morris works design staff and Nuffield Tools and Gauges, Ltd. It is actually the second machine for this class of work designed and built by the same firm, as one was supplied to the Morris works some twenty-seven years ago. Although the use of this first machine was dropped owing to certain technical troubles, it was probably the first transfer machine in the world, and it anticipated the machines introduced elsewhere very many years later.

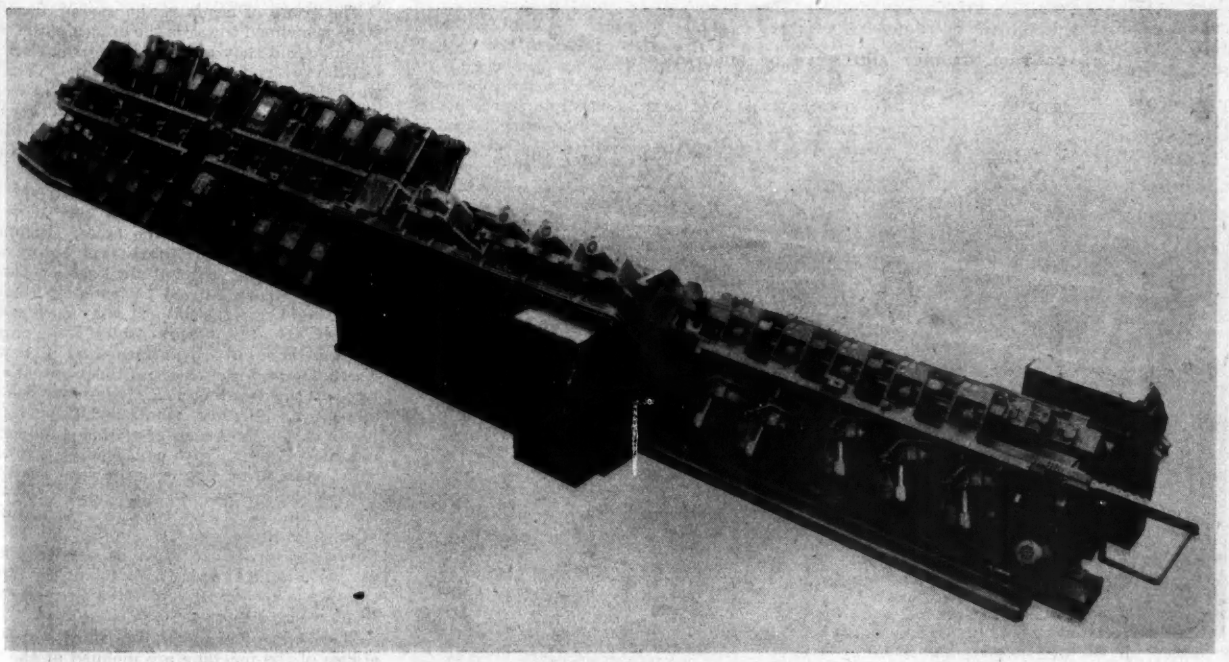
The new transfer machine replaces eighteen other machines and it requires one setter and two operators, as compared with the thirteen operators previously engaged. In the eighty seconds taken to pass through the machine a gearbox casting has all of its drilling, tapping, reaming, internal milling, and spot facing operations carried out. In the course of this work forty-eight holes are drilled and reamed or tapped, and six inside and five outside faces finish-machined to a constant degree of accuracy. Some idea of the operations performed can be obtained from the drawing we reproduce of a gearbox casting.

Certain preliminary machining operations carried out before the castings are delivered to the transfer machine provide the means of location at each stage. In these preliminary operations the end faces of the casting are milled parallel to within plus or minus 0·002in on length and the cover face milled square with these ends. The large ball race holes in the end faces are bored to within 0·0007in on diameter with their centre line at a precise distance from the top milled face. Two of the cover bolt holes are also drilled, and, together with the main bores and milled top face, are used for location of the gearbox casting in the transfer machine.

The transfer machine actually comprises a single line of four main banks of units, each of which is a machining stage incorporating a group of spindle heads. At the feed end of the machine up to six castings are stored on a short length of idler roller conveyor, along which they are pushed by an operator until they are picked up in turn by a set of live rollers. These live rollers carry the castings up to a stop at the head of a reciprocating transfer feed bar above a line of support rails running the full length of the machine. This transfer bar is fitted with a series of feed forks and it automatically slides the castings along the support rails between machining operations. At the end of each machining operation the transfer bar is turned through 90 deg. by a hydraulic cylinder to raise the feed forks clear of the castings. The bar is then retracted longitudinally by hydraulic-cylinder-operated push-rods for a distance equal to one-half pitch of the working stations, i.e., 10in. It is then turned



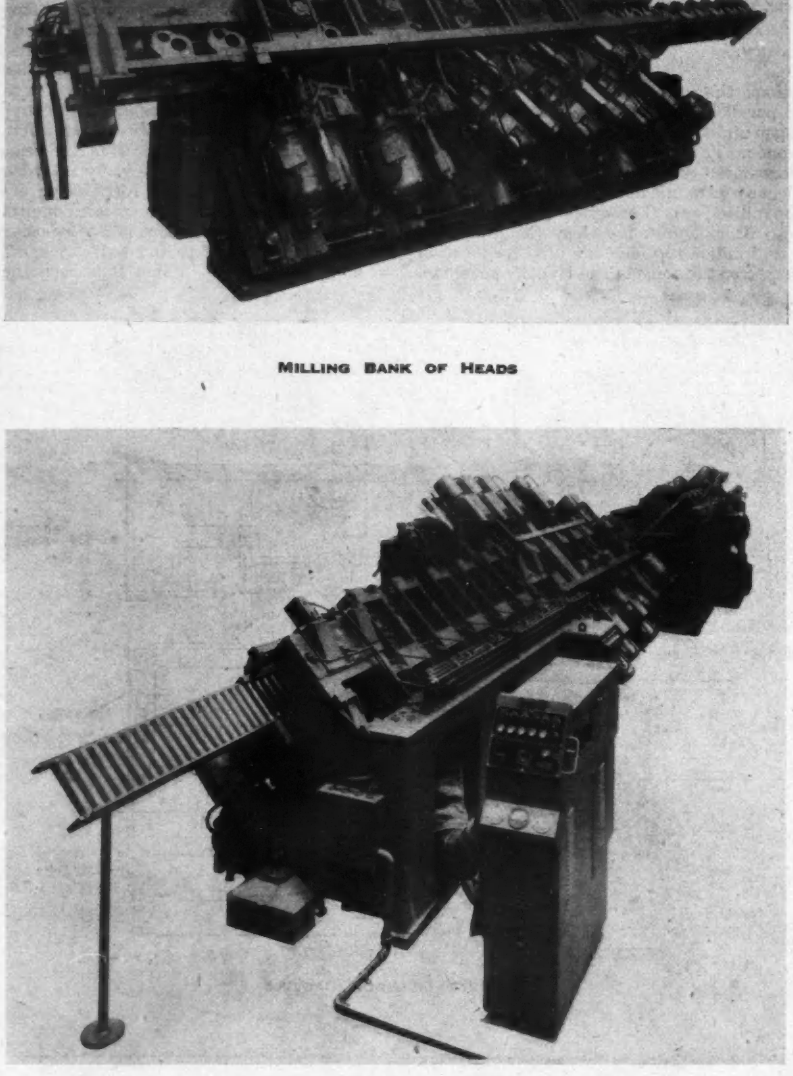
MACHINED GEARBOX CASTING



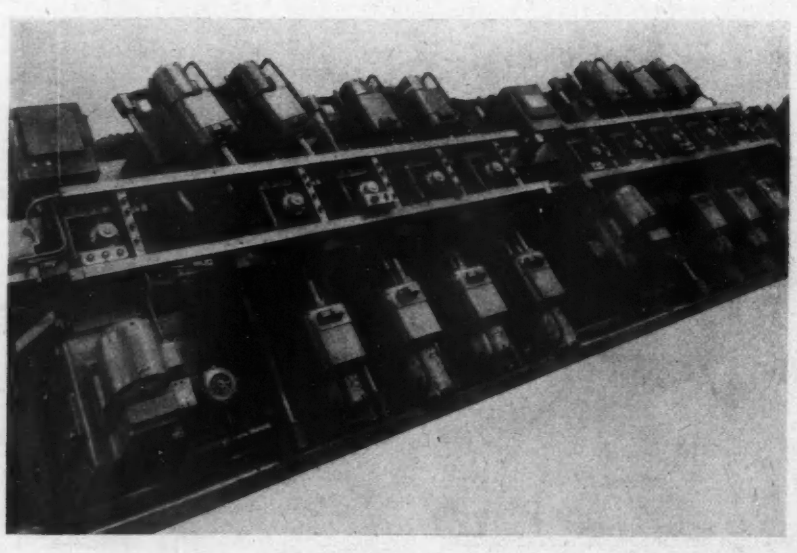
GEARBOX TRANSFER MACHINE

TRANSFER MACHINE FOR GEARBOXES

MILLING BANK OF HEADS



CONTROL CABINET AND REAR OF MILLING BANK



FOURTH BANK OF MACHINING HEADS

to replace its forks between the castings, and its push-rods again operate to move it and the line of castings forward for the next machining cycle.

Although the transfer bar and push-rods act as a single unit, they are actually individual assemblies on each of the machine groups and are operated by their own systems of hydraulic cylinders, which are all interlocked.

At each stage of the machine the group of spindle heads is mounted on a rigid steel frame which is inclined at an angle of 45 deg. to the floor. This arrangement sets the height of the casting support rails, &c., about 4ft above floor level and facilitates access to the heads for setting and checking. The castings rest on the support rails on their machined cover faces and at each machining station they are located by hydraulically operated plungers which register in the main end bores. When the line of castings has been moved along the rails by the transfer bar the plungers of all the head fixtures have to be positively registered and the castings clamped before any machining operations can begin.

The spindle heads of the machine are generally of similar construction, each consisting of a rigid slide carrying a motor which drives one or a group of spindles through a gearbox. These head slides are mounted on large-diameter hardened and ground guide bars, and all the slides except those of the tapping heads are actuated by disc cams in the base. The feed cams in each group of heads are driven by a common shaft rotated by a separate motor through a gearbox. The tapping heads are not fed by cams, although their drives are interlocked so that their movements are concerted with those of the other heads during the machining cycle. At a number of the machining stations a pair of heads, one above and one below the casting support rail, are arranged to work on opposite faces of the gearbox. In these cases the cam drive of the lower slide is coupled through links to the upper slide so that the two heads move in unison to feed and retract the tools. Each head slide is fitted with a limit switch, which is operated when the head is fully retracted at the end of a machining operation. All of the limit switches on the machine are interlocked and until all of the slides are fully retracted the transfer bar mechanism cannot operate to feed the line of castings forwards.

At the first stage of the machine five spindle heads set below the guide rails are tooled to mill faces on the inside of the gearbox casting. The first three of these heads are inclined to impart the necessary angle of approach to the cutters.

The group of heads at the second machining stage is inclined towards the opposite side of the machine and they are tooled to drill, ream and tap the two end faces of the castings. The first three heads are arranged in pairs with the units above and below the support rail, and they drill, ream and spot-face holes. A fourth head below the rail then chamfers a single hole before a fifth pair of heads reams holes in each end face of the castings. The castings then pass to a station where compressed air jets blow any swarf or chips clear of the holes. Before the castings pass on to the final tapping operation of the machining stage, all the holes are checked and their depth gauged by gauging heads set above and below the support rail. Each gauging head carries a set of plugs, and if these plugs do not register or fail to penetrate to the full required depth, forward movement of the pneumatic feed ram of the head is halted and the machine stops. As already mentioned, the tapping heads at the final station of this stage are not mounted in slides with cam feed. Each of the spindles in these two opposite heads is spring loaded and has an individual lead screw drive from a motor-driven gearbox. This driving motor is fitted on the lower of the two heads and drive is transmitted to the upper one by means of a shaft. Each of the tapping spindles is fitted with a clutch set to slip should overloading occur.

The bank of heads on the third and fourth stages of the machine are inclined at the same angle as the first stage. In the third stage the

holes in the cover face and one of the holes in the bottom of the castings are drilled and tapped. Between the drilling and tapping operations the swarf is blown clear of the casting and all the holes are gauged on a similar head to that used on the second stage of the machine.

In the fourth and final stage of the machine, to be seen in another of our illustrations, the holes in two sides of the castings are drilled, faced, reamed, and tapped. For these operations it is necessary to turn the castings through 90 deg. at each head station and back again into line for the feed movement along the support rails. This turning is effected at each machining station by a fixture, which has guide and location faces arranged in line with the support rails. When a casting is fed on to the fixture it is locked by similar hydraulically operated plungers to those at the other machining stations. All of the fixtures are connected to a coupling rod by links and when all the castings they carry have been locked in position this coupling rod is actuated by a hydraulic cylinder to turn the fixtures through 90 deg. At the end of the turning movement the fixtures are located by detent plungers and, together with the coupling rod, locked for the machining operation.

At the end of the support rails the gearboxes pass on to a short length of roller conveyor leading into a washing and drying unit, which adds 30ft to the 60ft length of the transfer machine. All of the swarf and chips produced during the machining of the gearbox castings gravitate down the sloping plate frames of the machine, and fall into vee-shaped troughs on each side. These troughs are actually shaker conveyors driven by geared motor units and they deliver the swarf into wheeled bins at the end of the machine line.

From the above notes it will be appreciated that practically all movements on the machining sequence are controlled by the hydraulic system. By linking the valves of these hydraulic units with the operation of limit switches on the heads, feed and locking mechanisms, &c., the complete operating sequence of the machine is predetermined and controlled from a single compact cabinet. Housed in the base of this control cabinet is the main hydraulic pump unit, from which pressure fluid is distributed to the feed lines through a group of valves operated by a camshaft. The limit switches energise solenoids arranged in a line in the upper part of the control cabinet. These solenoids operate a series of ratchet escapement wheels keyed on a motor-driven shaft coupled through a roller chain to the hydraulic valve camshaft. As the solenoids are energised in turn in the sequence of operations the ratchet shaft is freed to rotate and, in turn, it rotates the hydraulic valve camshaft to admit fluid to the respective lines for the next sequence of operations.

At the end of the ratchet wheel shaft is keyed a disc which has engraved around its face the operations at its various settings. A segment of this plate, which is visible through a window in the cabinet, shows the operation being performed at any time. In the event of anything going wrong on the machine—such as a locating plunger failing to go right home or a plug gauge not penetrating the full required depth—the appropriate limit switch is not operated and its solenoid in the cabinet is not energised. This causes a red lamp to light up on the head in question and the machine stops; at the same time the particular operation involved is shown by the indicator disc at the control station. With this light signal and operation indicating arrangement the cause of any stoppages are immediately shown and quickly traced to the point at fault.

Mersey Passenger Ferry "Egremont"

THE Mayor and Corporation of Wallasey have recently taken delivery of the twin-screw diesel-engined passenger ferry, "Egremont," which has been constructed by Philip and Son, Ltd., after successful trials in Start Bay on March 27th, when a mean speed of 13·1 knots was attained under conditions of moderate gale, rough sea and heavy ground swell.

The vessel, which can be seen in our illustration, has a length between perpendiculars of 145ft, by 34ft breadth moulded, by 12ft 3in depth moulded, and is designed to operate at a mean load draught of 7ft 4in. A regular ten-minute ferry service is maintained between Seacombe and Liverpool by the ferries undertaking of the Corporation of Wallasey, and the ship has been built to fulfil the required conditions and to comply with the regulations of Lloyd's and the Ministry of Transport. When on ferry service the ship can accommodate 1472 passengers, and she is classed and equipped to carry 700 passengers when engaged on cruises on the River Mersey.

During the trials the excellent manœuvring abilities of the ship were demonstrated, and a turning circle having a tactical diameter of twice the length of the ship was achieved with both propellers running full ahead. Steering is effected by twin balanced rudders operated by electro-hydraulic steering gear, which is supplied by Brown Brothers, Ltd., and fitted with a special device to change automatically from power drive to hand steering in the event of failure of the electric current. The rudders are slightly inboard of the line of the propeller shafts which are exceptionally widely spread. This arrangement has been adopted with the object of promoting the effect of spinning the ship so that she can be breasted rapidly toward, or away from, the landing stage. With such widely spread shafts the orthodox form of bossing was not possible. Accordingly it was eliminated, the steel stern tubes being placed substantially outboard.

The accommodation for the passengers is centred in a large saloon which extends for the full width of the main deck and has glazed sides and front to give an unobstructed all-round view. A spacious dance floor is made available quickly by the removal of the centre seats, while the side seats are of swivelling design so that passengers may watch the dancing or observe the outside surroundings. An observation shelter is placed on the boat deck, while other amenities such as smoke rooms and buffet are to be found on the lower deck, at the aft end of which is the crew accommodation. A certain amount of aluminium alloy plate and section material has been employed in the construction of the superstructure, including the observation shelter, wheelhouse, wing navigating cabs and funnel. The formidable problem of the prevention of air-borne engine noise from reaching the accommodation, has received consideration and considerable success has been achieved in this by fitting sound-absorbent insulation in the machinery spaces. A twin problem was the elimination of structure-borne noise due to vibrations set up by the machinery and to assist in this purpose the main engines were mounted on resilient chocks of "Tufnol."

Two Crossley "H.R.N." direct-reversing, two-stroke diesel engines form the main propulsion machinery. Each has eight cylinders of 10·5in diameter by 13·5in stroke, develops 600 b.h.p. at 330 r.p.m., and drives the propeller shafting, which is carried on S.K.F. roller-bearing plummer blocks, through a Michell pattern thrust block. Cooling of the engines is by fresh water operating in a closed circuit. This is normally independent of the fresh-water-cooled auxiliary diesel engines, but provision has been made for warming up the main engines by circulating hot water, from the auxiliaries, through the engine jackets. The main engine controls are led to a central position conveniently placed near the indicators and gauges, and provision is made for control of the main machinery from the bridge.

For the purification of the lubricating oil and the diesel fuel, Sharples purifiers and "Streamline" filters have been provided. Starting air is contained in two main air receivers, each of 55 cubic feet capacity, which are supplied by two Reavell compressors, each capable of delivering 50 cubic feet of free air at 350 lb per square inch pressure per minute. Electrical power for operating the auxiliary machinery and the ship's services is supplied by two 50kW, 220V Metropolitan-Vickers generators, driven by Ruston and Hornsby diesel engines. For port and emergency purposes there is a 6kW generating set coupled to a hand starting engine which also drives a small emergency compressor. In keeping with the other efforts to damp hull structure vibration the generating sets are mounted on "Silentbloc" resilient supports.

MERSEY PASSENGER FERRY "EGREMONT"

Technical Reports

Deterioration of Structures of Timber, Metal and Concrete exposed to the Action of Sea Water. Nineteenth Report of the Committee of the Institution of Civil Engineers. Second edition. By J. Bryan, M.Eng. London: Institution of Civil Engineers. Price 5s.—This is a general summary of experimental work carried out to date on timber. Some general notes regarding timber in home, colonial and foreign waters are given, including tests by corresponding members, and investigations carried out at the Marine Biological Station, Plymouth. The latter include experiments on the breeding of the teredo and toxicity tests in teredo, limnoria and chelusa, the various toxic concentrations being listed. A series of tests on treated timbers exposed in the sea are described, a record of the tests are tabulated and photographs of specimens are given. The results of the tests at Singapore, which were still in progress when the first edition of the report was published, are included. The report concludes with a discussion on experimental work and the general conclusions are that no timber in its natural condition is absolutely immune from attack, although certain species are highly resistant. Coal-tar creosote impregnation gives timber almost total immunity to marine borer attack in home waters and ensures long life in tropical waters. Another preservative which might be equally effective is Celcure.

Shotfirer's Carriage for a Mechanised Anhydrite Mine

In connection with a comprehensive mechanisation scheme now being carried out in the anhydrite mine of Imperial Chemical Industries, Ltd., a new design of shotfirer's carriage has recently been placed in service. The platform of this carriage is designed to carry a load of up to 1 ton and can be raised or lowered parallel to a working face between 3ft and 18ft above floor level, to facilitate the work of placing the charges of explosive and stemming the holes.

DURING the past few years an important scheme of modernisation and mechanisation in the anhydrite mine of Imperial Chemical Industries, Ltd., at Billingham has been making steady progress and has now reached an advanced stage. The anhydrite produced in the mine is used in the manufacture of fertilisers, which form one of the more important products in this section of the I.C.I. organisation. The scheme now in hand involves the introduction of new mining methods, which, combined with the use of a number of specially designed machines, is intended to make possible a steady production of 13·5 tons of anhydrite per man-shift. As the mine is not gaseous and an efficient system of ventilation is employed, extensive use is being made of diesel engines for the transport of men and materials underground and for the driving of equipment.

Under this system of working, the anhydrite is blasted from the front face in workings some 24ft wide and 18ft high, and the fragmented material is loaded by mobile boom loaders on to diesel-engined dumper trucks of 10 to 12 tons capacity. These trucks transport the ore to a 450-ton bunker, which feeds down through a live-roll grizzly to a jaw crusher in which the lumps are reduced to a 7in to 8in cube. From the crusher the ore is carried by a belt conveyor to a 180-ton bunker at the foot of the winding shaft, whence it is raised to the surface by skips.

A particular difficulty encountered when mechanising a mine of this kind is the dense dust which is created when drilling, blasting and handling the anhydrite. This dust penetrates into all parts of the equipment and if it gets into any lubricated part it tends to build up and eventually pack sufficiently hard to "freeze" a bearing. It is not possible to prevent formation of the dust by water spray methods, as with a small degree of humidity it sets the rock hard. It will be appreciated that extensive mechanisation and the economic running of plant under these conditions calls for particular care in design to avoid unduly frequent servicing.

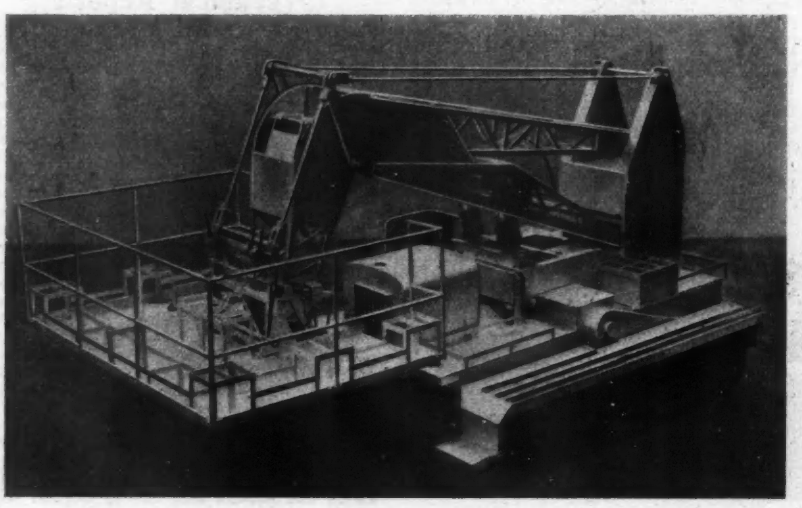
As already mentioned, the mineral is obtained from the vertical face of a working 24ft wide by 18ft high, and this face is prepared by drilling and charging about sixty holes, which are fired in one round, using electric delay detonators. For this work of drilling the holes and then charging and stemming them, two special rigs have been developed, together with a third rig used after blasting for scaling the roof. In the course of a recent visit to the mine we were able to inspect one of these special machines—a mobile shortfirer's carriage, which is the first of the three machines to be put into service. The other two machines are now under construction and will be put to work in the near future.

THE CARRIAGE IN USE

Before dealing with the construction of this shotfirer's carriage, which can be seen in the illustrations on this page, some of the requirements specified for its design are worth recording. As the machine was to work on irregular floors of hard rock with many pockets of fine loose material, it was decided to use a track-mounted carriage. It was to be driven by a diesel engine complying with mining regulations in respect to exhaust gas analysis, and of a capacity to enable the machine to negotiate gradients of 1 in 8 or more. The carriage had to be able to negotiate 18ft wide right-angled corners without reversing in passing through old workings, and operate in places 18ft to 24ft wide with an available headroom of 12ft to 22ft. The platform of the carriage from which the blast holes have to be charged was required to carry a maximum load of 1 ton and be sufficiently large for four men to work upon. Duplicate controls for moving the platform had to be arranged at the working position and at the carriage driving position. The platform had to overhang the vehicle tracks and be capable of being raised or lowered parallel to an undulating working face without moving the carriage as a whole. As the machine was to be used when handling explosives and electric detonators, it was desirable that no electrical equipment was used or fitted to it.

When the specification of the carriage had been decided upon difficulty was encountered in placing an order for the complete equipment with any single firm of makers. Eventually orders for various units were placed with a number of firms and the construction of the complete machine entrusted to F. Taylor and Sons (Manchester), Ltd., of Salford, who worked to the designs prepared by the I.C.I. engineers. Ruston-Bucyrus Ltd. supplied the tracks, axles, steering clutches, &c., which are similar to those used in the firm's "27t" blast hole drill equipment. The power unit consists of a Perkins P.4. diesel engine, which drives through a Ford clutch and gearbox, and the platform and its supporting gear is a modified arrangement of the "Jumbo" constant-level moving platform mechanism made by F. Taylor and Sons (Manchester), Ltd.

The machine is carried on tracks 11ft 9in long and 9ft 10in wide overall, fitted with standard 10in treads and having a mean ground pressure of 10·8 lb per square inch. These tracks are chain driven and tied together by a solid round axle at one end and a pivoting axle at the other. The main members of the rigid chassis frame consist of four 10in by 3in channels, each attached to the main track axle through axle blocks at one end and tied together by a 10in by 5in joist at the other end. At the centre of this joist there is fitted a 2in diameter pivot frame which forms the front suspension link with the pivoting axle. The two innermost main channel members are connected at the middle by a pair of 6in by 3in channels, which form the base mounting for the



SHOTFIRER'S CARRIAGE

transmission bevel gearbox. With the form of suspension used relative vertical displacement of the tracks can take place during operation of the machine without the full effect being transmitted to the chassis.

The output of 34 b.h.p. at 1500 r.p.m. from the diesel engine is transmitted through the clutch to a Ford "7V" four-speed and reverse gearbox in which only the first gear (ratio 6·4 to 1) and the reverse gear (ratio 7·82 to 1) are used. A bevel reduction gearbox with a 1½ to 1 reduction has its input shaft coupled to the main gearbox through a "Layrub" coupling, and it has separate output shafts to each steering box. This reduction gearbox was supplied by Hardypick, Ltd. Each of its output shafts drives a steering box consisting of a separate brake drum and a 4 to 1 reduction gearbox of sun, planet and annulus design, with a braked annulus acting as a steering clutch. The steering clutch and brake linkages are connected to provide simultaneous clutch and brake operation under control of a single lever at the driving position.

All movements of the working platform are hydraulically operated and the pump of the hydraulic system is chain driven from a power take-off on the gearbox.

As can be seen from our illustrations, the fabricated under jib, rear jib and sub-frame of the machine are similar in most respects to the standard units on the familiar "Jumbo" crane made by F. Taylor and Sons (Manchester), Ltd. The sub-frame box has a vertical extension to provide attachment for the constant-level tie rods of the platform and forms the hinge attachment for the under jib and rear jib. It also houses ballast and a 10-gallon oil fuel tank. Extending from the front of this sub-frame is a 6in by 3in channel frame carrying the two trunnion-mounted main lifting rams through which the under jib is operated.

The front end of the rear jib was modified to house the single-acting ram which is used to swing the front jib of the machine on its hinge. This ram has been coupled independently to the front jib by tie rods so that the full cylinder stroke is available for raising the jib. The front jib has been specially designed for the fitting of an extension so that it can be converted to a scaling jib for use in the scaler's carriage.

The working platform of the machine is mounted on a triangulated fabricated structure hinged to the end of the front jib and coupled through constant-level tie rods. The distance between the tie rod and the jib hinge is equal to that between the rear jib hinge and the tie rod hinges at the sub-frame box, and also to the tie rod hinge arm at the connection of the front and rear jibs. This arrangement of links ensures that the slope of the platform support structure remains constant, irrespective of the height of the platform.

At the front end the platform is hinged on its supporting structure, and through a nut and screw gear its angle to the horizontal can be varied to compensate for slope when the machine is standing on any gradient up to 1 in 4. This platform levelling means enables it to be maintained horizontal without need for adjustment of the constant-level tie bars.

The front of the U-shaped platform is 9ft wide and it is 7ft deep. It has a series of racks round its edges to hold sixteen 25 lb explosive containers and eight 63 lb clay boxes; racks for a further twelve explosive containers and twelve clay boxes are fitted on the carriage chassis.

As already mentioned, hydraulic power for operating the platform mechanism is supplied by a pump driven from the gearbox. This pump is a "Keelavite" gear unit with a rated maximum pressure of 2000 lb per square inch, which delivers fluid to two selector valves. One of these valves serves the front jib ram and the other the twin rams actuating the under jib. The single-acting rams are 5in diameter, that for the front jib having a 23½in stroke and those of the under jib 33in stroke.

The driving controls of the machine are arranged on one side of the carriage and from his seat the operator has a clear view when manœuvring. The workers on the platform have complete control of its movements up and down and in and out relative to the working face through two levers, and a third lever controls the engine speed. One of the movement control levers operates the hydraulic ram of the front jib for backwards and forwards movements of the platform, and the other lever controls the supply of hydraulic fluid to the under jib for raising and lowering the platform. Before power movements of the platform are effected the throttle control is used to accelerate the engine and increase the output of the main hydraulic pump. These three platform control levers can be clearly seen in one of our illustrations. By operating both jibs together the platform can be positioned at any height between 3ft and 18ft above floor level, and at most heights the platform can be moved horizontally over a distance of 3ft without need for moving the complete machine on its tracks.

When it is required to move the machine it can be driven at up to 1·25 m.p.h. forwards or 1·02 m.p.h. in reverse and it has a turning circle of about 25ft. A detachable hook is fitted on the front jib so that, if required, the machine can be used as a mobile crane, capable of lifting up to 25 cwt at 6ft outreach.

A Radiation Research Laboratory

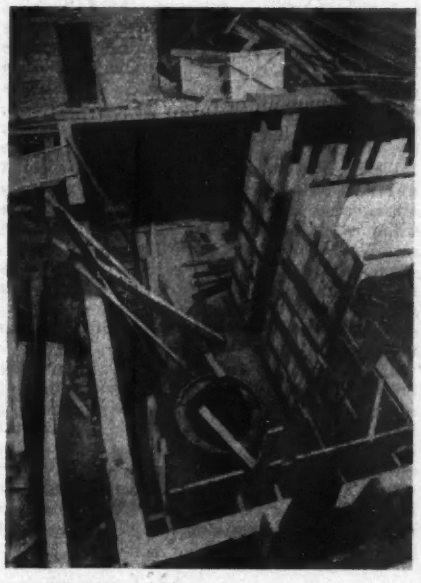
By P. P. STARLING, A.M.I.E.E.

TO provide permanent facilities for the study and development of methods of producing and measuring X-rays and other forms of radiation, especially at very high intensities, the Metropolitan-Vickers Electrical Company, Ltd., has designed and built a new laboratory of unusual construction.

Beyond certain limits, it is not possible to carry out experimental work of this nature in laboratories of normal construction, owing to the difficulty of safeguarding experimentalists and others in the vicinity against the effects of harmful radiations. The maximum safe dose for X-rays has been officially defined, and the problem is to ensure that the radiation reaching any person is well below that limit. This can be done by surrounding the source of radiation with concrete or other material of suitable thickness, or by locating it in such a position that direct and scattered radiation can pass harmlessly into space or into the ground.

It was decided, therefore, that the laboratory should consist of an underground portion to accommodate the source of radiation, and rooms above ground in which the control equipment could be housed and from which observations and measurements could be made in safety. A site for the laboratory was chosen adjacent to the existing radio laboratory, partly on account of the availability of appropriate staff, electrical supplies and other facilities, and partly because the high energy beam from equipment in the underground chamber could be conveniently directed horizontally away from occupied buildings into a safe zone provided by the ground beneath some railway tracks and a canal.

In the accompanying drawings we show a sectional view of the radiation laboratory and a plan (with part of the roof over the radiation chamber broken away and some of the slabs

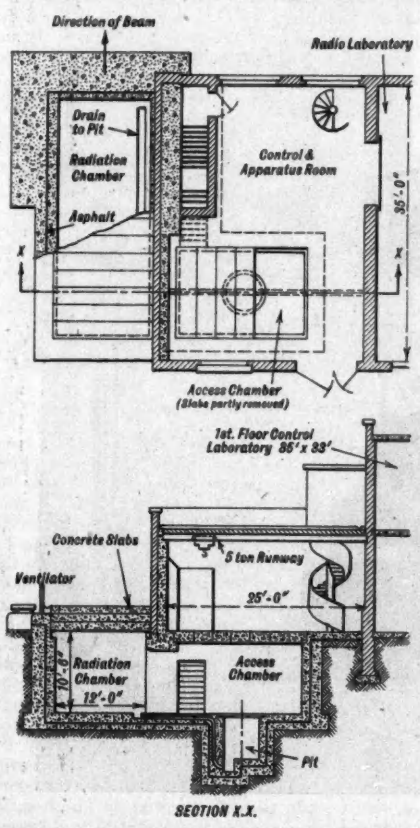


RADIATION LABORATORY UNDER CONSTRUCTION

over the access chamber removed). The structure consists of an L-shaped thick-walled concrete underground chamber, one arm of the "L" being the radiation chamber in which the beam producing apparatus is accommodated, and the other arm forming an access chamber. To intercept scattered vertical radiation, a 3ft thick concrete roof over the radiation chamber was found to be necessary. It takes the form of three layers of precast reinforced concrete slabs, finished overall with a plastic material to provide a watertight surface. This form of roof was adopted so that it could be readily removed at any time should the height of the chamber require to be increased or the building converted to some other use in the future.

Adjacent to the radiation chamber is a single-storey control and apparatus room with its floor at ground level. The other arm of the underground "L" extends beneath this room and is covered by a number of removable reinforced concrete slabs, 18in thick, which form part of the floor of the control room. A 5-ton runway is provided over this area, and, by removing the requisite number of slabs, apparatus may be lowered into the underground chamber, after which the slabs can be replaced. This method of access was adopted because modern equipment for producing high-intensity radiation can be of considerable weight and bulk.

A pit has been provided in the floor of the



PLAN AND ELEVATION OF RADIATION BUILDING

chamber beneath the removable slabs to facilitate the assembly of certain kinds of X-ray equipment before they are transferred to the radiation chamber proper. The bottom of this pit contains a sump from which cooling water discharged from apparatus under investigation may be pumped. Two automatically operated pumps are installed near the top of the pit.

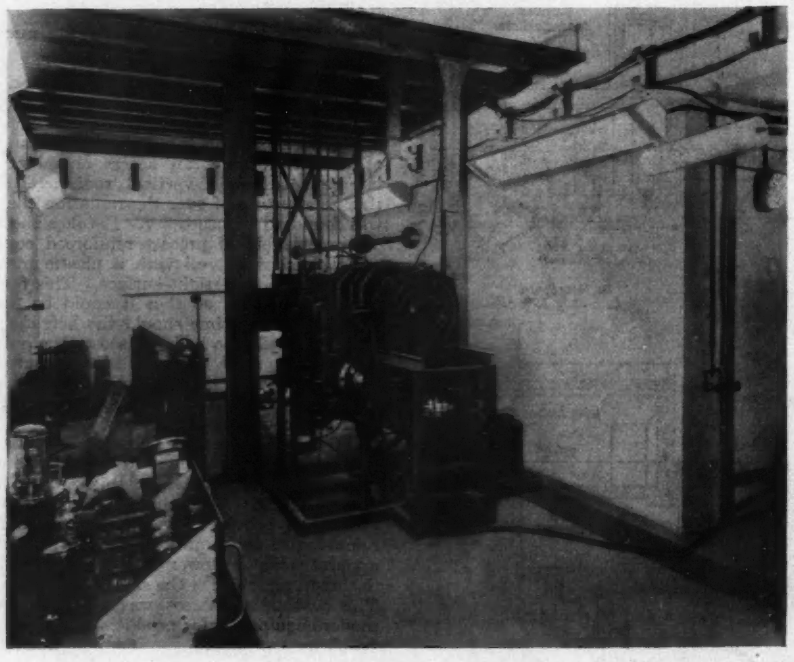
A staircase built in the thickness of the concrete is provided for access to the underground chamber. A second control and experimental room has been built on the roof of the existing radio laboratory with access from the ground floor room by means of a circular staircase.

The underground radiation chamber, which measures 30ft long by 12ft wide by 10ft 6in high, has concrete walls 6ft thick at the parts which may be in the direct path of the beam and 3ft thick elsewhere. The access portion of the underground chamber has walls 2ft thick. The walls and floor of the underground portion of the structure are all rendered waterproof by means of a layer of asphalt within their thicknesses. Ventilation is effected by an exhaust fan discharging into a duct which is shaped in such a manner that no direct radiation can pass through it. Heating is provided by oil-filled electric radiators in the radiation chamber and by hot water radiators in the laboratories above.

Owing to the sectional form of the roof of the radiation chamber it is not possible to support any great weight from it. To overcome this difficulty two 12in by 4in channel irons were let into the walls just below ceiling level, and movable transverse beams rest on these. It is thereby possible to support a small runway, with block and tackle, in any required position, by clamping it to a suitable number of these beams. Alternatively, apparatus can be secured directly to the beams, if it is necessary to do so. Metal cable brackets have been secured to the walls at suitable intervals to facilitate the installation of temporary cable runs.

One of the accompanying photographs shows the underground chamber during construction and the other shows a large microwave linear accelerator in the course of assembly in the radiation chamber.

It is convenient if experimentalists can carry out certain preliminary observations and measurements whilst they themselves are in the underground chamber, and, to afford sufficient protection, a number of interlocking barytes concrete blocks have been made, with which temporary baffle walls can be built at any desired position. Barytes concrete is used because it is denser than normal concrete and gives greater protection for a given thickness. A series of observations of the X-ray dose received at control and measurement positions while the accelerator is in operation has demonstrated that there is ample margin of safety even at the highest intensities.



LINEAR ACCELERATOR UNDER ERECTION

A 20-Ton Mobile Crane

WE illustrate on this page one of the 20-ton capacity mobile cranes, made by Steels Engineering Products, Ltd., of Crown Works, Sunderland, which are stated to be the largest machines of their kind built in this country. Two versions of the crane are made by the company. One is a lorry-mounted unit suitable for long-distance travelling and the other an all-electric unit suitable for working within a restricted area. In each case the crane is of similar design and construction, incorporating its own engine-driven generating unit, and having all its movements electrically driven.

A standard 30ft. structural jib is fitted to the crane and, by adding centre sections in 5ft. long increments, the jib can be extended to a maximum length of 80ft. With the machine jacked up on outriggers and using a 30ft jib, a maximum load of 20 tons can be lifted and slewed through a full circle at 10ft radius, or 5 tons at 30ft radius. With the machine on its wheels it can lift from 11½ tons at 10ft radius to 2½ tons at 30ft radius over the rear, and from 7 tons at 10ft radius to 2 tons at 30ft radius over the side. When an 80ft jib is fitted and outriggers are used up to 1 ton can be lifted at 73ft radius or 12 tons at 14ft radius.

20-TON MOBILE CRANE

The slewing base of the crane is built as an integral part of the vehicle chassis and incorporates a machine-cut internal rack and a path for the large diameter live ring of rollers on which the revolving superstructure rotates.

The superstructure is fabricated from mild steel plates and sections to form a rigid platform for the machinery and support for the hoisting gear.

The generating gear situated at the rear of the superstructure comprises either a Ford 70 h.p., 2500 r.p.m., petrol engine, or a Perkins 80 h.p., 2500 r.p.m., oil engine, driving a variable-voltage, shunt-wound, commutating-pole generator. This generator has a nominal rating of 23kW at 2200 r.p.m., and is specially designed to maintain a stable voltage which drops approximately in proportion to the engine speed. It supplies current to the three main motors for hoisting, derricking and slewing. Each motor is a half-hour rated series-wound commutating-pole machine. The hoisting motor has a nominal rating of 32 h.p. at 1200 r.p.m., the derricking motor 12 h.p. at 1000 r.p.m., and the slewing motor 6 h.p. at 500 r.p.m.

The hoist motor is fitted with a 12in magnetic brake and its drive is taken through a totally enclosed worm gear reduction unit, the hoist barrel being driven from the worm unit slow-speed shaft. Loads can be raised on one, two three or four falls providing that the load on the hoist rope does not exceed 5 tons. With a single line, pulls of 11,000 lb, 5000 lb and 2500 lb can be effected at speeds of 60ft, 90ft and 120ft per minute respectively.

The barrel of the jib rope derrick gear is driven through a worm reduction gearbox and this drive also incorporates a magnetic brake. When derricking, the movement of the jib from maximum to minimum radius is effected in 90 seconds.

An 8in magnetic brake is fitted on the motor shaft of the slewing gear and the drive is taken through a vertical worm reduction unit. A machine-cut pinion at the lower end of the reduction wormwheel shaft meshes with the rack in the slewing base. A slipping device is incorporated in this drive to prevent shocks being transmitted to the gearing when starting and stopping the motor.

The electromagnetic brakes fitted to each of the motions are normally closed and held in the "on" position by coil springs. The brakes are automatically applied when the current supply is interrupted either intentionally or accidentally. When current is passed through a circuit a solenoid is energised to lift the brake shoes clear of the drums.

In the driver's cab, which is completely

enclosed, the hoist, slew and derricking control levers are arranged on a panel within easy reach in front of the operator. Contactor reversing controllers actuated by the levers carry the main current and are connected to limit switches which operate when the main current is broken in the appropriate circuit. Speed control of motions is through the engine throttle pedal.

When operating the crane the controller lever for the desired motion is moved to the required position with the engine running at slow speed and then, through the throttle pedal, the speed of the motion is regulated. Any motor can be switched into circuit for either direction by moving the appropriate lever to the forward or backward position. The motor concerned is thereby directly connected to the generator, no rheostats or relays being used. The low voltage generated with the engine running at slow speed when moving a controller is not sufficient to move the motor or release the solenoid brake. Acceleration of the engine to speed up the generator then gives a smooth increase in voltage until the potential is sufficient to release the brake and cause the motor to rotate against its load. Should it be required to put an additional motion into operation the throttle pedal is momentarily released and the other controller or controllers switched in, then the engine can once again be accelerated up to the required motion speed. When the throttle is closed all the magnetic brakes are automatically applied.

The lorry-mounted crane, illustrated opposite, is carried on a rigid welded frame, having deep rolled steel joists as side members, and is supplied as a six-wheel, four-wheel drive, or a six-wheel drive unit. It is propelled by a Leyland six-cylinder, 125 h.p. oil engine, through a main gearbox with five-speed forwards and reverse and an auxiliary gearbox.

With the main gearbox the machine has road speeds of 27, 15, 8, 5 and 3 m.p.h. Using the auxiliary gearbox when under severe road conditions, the respective speeds are 14, 11, 6, 4 and 2 m.p.h. A standard heavy-duty Kirkstall front axle is fitted to the chassis and the rear bogie has fully floating mid and rear axles with overhead wormgear. The rear wheels of the chassis are carried on rocking beams pivoted at their centres to brackets attached to the frame, and these beams are designed to distribute the weight on all four wheels of the bogie. Brakes on all six wheels are operated by compressed air and a hand-operated brake acts on the four rear wheels only.

A Showroom for Machine Tools

In order to provide accommodation for displaying and demonstrating the machine tools made by some twenty-four British, American and Continental manufacturers it represents, the Rockwell Machine Tool Company, Ltd., of Welsh Harp, Edgware Road, London, N.W.2, recently extended the showrooms adjoining its offices. With the new 150ft long by 40ft wide extension, these showrooms now cover an area of some 12,500 square feet and provide an opportunity for prospective purchasers to inspect machines under excellent conditions.

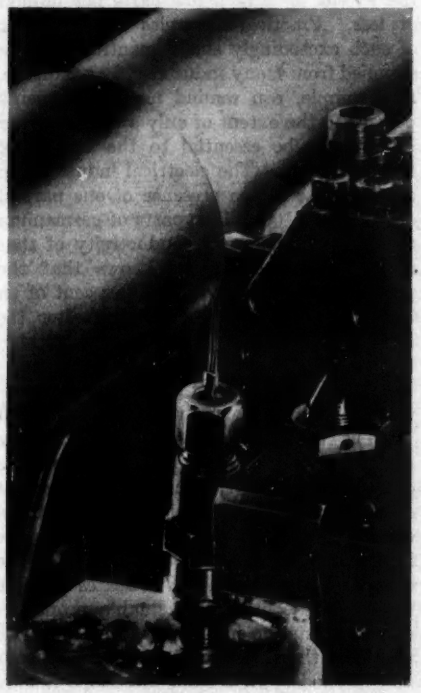
In showrooms of this kind ample lighting is of particular importance, where detailed examination of all parts of a machine is frequently called for. For this reason care has been taken to provide good natural lighting by a well-glazed roof and artificial lighting by numerous fluorescent tubes. Machines at any part of the floor can be quickly connected to the power supply through power points for demonstration running purposes.

As machines are constantly being moved in and out of the building a hard wearing floor of dust-free granolithic concrete has been laid down, and ample means of handling are installed. A 5 ton overhead travelling crane serves the full length of the building and its rails are extended through the continuous hinged shutter doors at one end for the direct handling of equipment on lines. The unloading bay itself is also provided with a 12½ ton gantry fitted with a 10 ton electric block, and a fork-lift truck used for moving machines can be used with a special gantry.

To enable the company to show films demonstrating the construction and use of machines a small air-conditioned projection room has been built in one corner of the new extension. With the help of a library of films the information obtained in the actual demonstrations carried out in the showrooms can be supplemented to give fuller details of the possibilities of particular machines.

Lubrication and Cooling of Cutting Tools

Two interesting developments in the cooling and lubricating of cutting tools have been introduced recently by the Gulf Research and Development Company, a subsidiary of the Gulf Oil Corporation, of Pittsburgh. Comprehensive tests have indicated that these developments, which are respectively known as the "Hi-Jet" lubricating and cooling system and the Gulf "Hi-Jet" oil, can increase the life of high-speed steel cutting tools from six to twelve times, and of carbide tools from three to five times, and that cutting speeds can be doubled. These improvements are said to be obtainable without any radical changes in existing equipment and at a moderate cost. With the "Hi-Jet" method of lubricating and cooling, small high-speed jets of the special oil are directed on the cutting edge of the tool not from above, but from below, as shown in the accompanying illustration. The streams of oil pass upward through the wedge-shaped air space between the work and the side relief face of the tool, and are aimed at the line of contact between the work and the cutting edge. Part of the oil is forced past the cutting edge and between the chip and the tool, thus efficiently lubricating the tool and improving the rate at which heat is removed. The fact that the chips leaving the contact area are coated with oil is considered to prove that the oil actually passes the cutting edge. The pressure of a few hundred pounds per square inch used in this method is not sufficient to force liquid oil past the cutting edge, where a pressure of 50,000 lb per square inch or higher is encountered but, since the edge temperature is well above the boiling point of the oil, the liquid is vaporised and thus can be forced through the slight irregularities which exist in both the cutting edge and the work surface and which form tiny passages. In the process of vaporising, the oil picks up considerable heat from the most critical area—the cutting edge. This action partially accounts for the improved cooling effect. The flow of excess liquid oil outward along the under-side of the cutting edge also removes heat. The condensed liquid oil is trapped between the tool and the chip, where it is needed to reduce frictional resistance to chip motion. The entire lubricating and cooling unit consists of a jet, or a series of jets, flexible tubing, and a small motor-driven pump, capable of providing a pressure of 400 lb per square inch.



"HI-JET" LUBRICATING AND COOLING

In the course of the experimental work it became evident that the nature of the oil has an important effect on the operation of the system. With some oils, the results are only slightly better than with the conventional overhead flood method, but with others the results are outstanding. Because of this, an intensive development programme was launched to determine what oil properties affect the efficiency of the "Hi-Jet" system and to incorporate all the desirable properties into one oil that would produce the best possible results. More than fifty different oils and additives were investigated, and, one by one, the less desirable ones were discarded. This entailed the development of thirty-five new oils, in addition to the testing of over fifteen existing oils. In the test work, every effort was made to reduce all variables to a minimum. All tests were made on a standard Warner and Swasey turret lathe, which was rigidly constructed. Specimens of each grade of steel were taken from a single heat and carefully heat-treated to maintain the highest possible degree of uniformity in machinability. A tool-post dynamometer employing the air gauge principle was developed to measure the forces in the single-point cutting operations. The temperatures generated at the cutting edge were measured by using the work and tool as a thermo-couple. The tools were carefully ground to a standard finish in jigs. No hand stoning was permitted because of the difficulty of controlling this operation. The tool dimensions in all cases were those recommended for the grade of steel tested. In an effort to shorten the duration of the "Hi-Jet" test from a matter of days to a matter of hours, the test was set up so that each tool failed in from three to six minutes when cutting without lubricant.

The majority of the more than 600 tests were made on S.A.E. 1020, A.I.S.I. 3140 and S.A.E. 3150 steels with high-speed steel tools. However, additional tests have been made on stainless steel with high-speed steel tools, and another series of tests was made on S.A.E. 3150 steel with carbide tools. Good results have also been obtained in machining titanium alloys. One of the most interesting characteristics of these tests was the consistency of the results produced with the new system. Tool life under test conditions was found never to vary more than ±25 per cent, and was usually within ±10 per cent for a given set of test conditions. Additional tests were run on a production basis on "Inconel M" and A.I.S.I. 8742 material with carbide tools. On aircraft valves made of "Inconel M," the number of pieces machined per tool ground by the old method was extremely low because of the tough, gummy nature of this nickel-chromium alloy. The operation was performed on a Bardons and Oliver turret lathe, with the work rotating at 67 surface feet per minute, a tool feed of 0·065in per minute and a depth of cut of 0·075in. When the new system and oil were applied to the operation, the number of pieces machined before tool regrinding was necessary was increased at least threefold. Five streams of oil were directed on the 0·312in wide cutting edge of the carbide tool. In the second group of tests, on a 3in diameter shaft of A.I.S.I. 8742 steel, the "Hi-Jet" method gave a 3 to 1 improvement in tool life.

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A PATTERN FOR PROGRESS

THERE are few thoughtful people to-day who do not anticipate a quickening of achievement and of progress in the years immediately ahead of us. It is when one can stand aside for a moment and consider past achievement and present promise that the acceleration in modern industry can be perceived. So remarkable has been the forward surge of engineering practice in the last decade or so that it is natural to wonder whether it is likely, even possible, for the advance to continue at the same pace. A consideration of the achievements of modern physical science and of engineering and metallurgy provides assurance not only that progress will continue, but that we can also expect yet further acceleration. There is a desire on the part of most of us to attempt to foresee something of the pattern of that progress, so that we may plan our part in co-operating with it. Something of that pattern is revealed in the article on another page of this issue, under the title "Metals and Alloys of To-day and To-morrow." The matter in that article may possibly stimulate thought by reminding us of the direction in which progress is being made in metals and alloys and something of what has already been achieved.

It will be noted that there are certain clear trends toward, for example, the use of light, or, at least, lighter metals. There is the ever-present urge to attain better physical properties without the sacrifice of economic advantages, and the constant preoccupation with methods giving closer and more accurate control of metallurgical operations. The substitution of cheaper or more abundant elements for the rarer and more costly substances provides another set of problems and it is natural to seek for factors which can play a part in some or all of these matters. We can see something of one such factor in the modern attitude toward matter. We are much less preoccupied to-day with its external appearance and vastly more interested in its minute atomic structure. It is of great importance to know not only the gross constituents, and the larger impurities of the metals and alloys we handle, but also those minor constituents that may be present to the extent of only a few parts per million or less. Practical examples of the power of such exceedingly small quantities can be supplied from many industries. Agriculture, for example, can remind us that elements present to the extent of only a few parts per million can be essential to the success of crops or flocks. The electrical industry can cite the case of the presence of one part of antimony in 100 million parts of germanium doubling the electrical conductivity of that metal. The metallurgist knows that the presence of as little as 0·001 per cent of an interfering element can seriously alter the behaviour of an alloy under stress at high temperature! The gathering of such knowledge calls for the use of refined and accurate methods of analysis and testing. It does not lead us to think that all impurities are necessarily evil, nor does it demand standards of universal purity that would inhibit economical mass production of materials in common use. It directs attention to the importance of an exact knowledge of the causes of phenomena. It indicates possible methods of controlling valuable properties and contrasts the empirical knowledge of the past with the potentialities of present means and methods. In certain directions it may be suggested that greater care will be necessary in the preparation and refining of metals, and that higher standards of purity will be essential. That is generally true, but it does not impose onerous conditions in every case, and in two very important directions it may be useful to remember the comparatively recent introduction of ductile or nodular cast iron, an outstanding British contribution to ferrous metallurgy, and the investigations into the cause and control of age-hardening processes. Ductile or nodular cast iron is produced by the introduction of either cerium or magnesium metal in the proportion of about one-quarter of 1 per cent into molten cast iron. Its effect upon the strength, ductility and structure of cast iron so treated is now common knowledge among engineers and foundrymen. It might be expected that there would be limitations on the composition of the iron that could be used, and while that is so they are not so stringent as to seriously limit the use of the process. Silicon, for example, can vary over a wide range while manganese has a notable effect on the matrix, but does not affect the formation of the spheroidal or nodular structure which gives to the treated metal its new characteristics. But it is clear that a number of elements usually present in very small amounts can affect the results, and their influence calls for further research and will probably yield valuable information.

In the non-ferrous field research into age-hardening has provided an explanation of the mechanism of this phenomenon and a pointer as to the part played by those elements capable of entering into solid solution with one or other of the metals present in an alloy. It has shown that one group of elements can accelerate and another inhibit, or, at least, slow down the hardening. More accurate and wider knowledge of all these matters will mean more accurate control and more economical production. Every advance in these directions facilitates better design and more accurate functioning of assembled parts. It does provide a pattern of progress that is logical and understandable while holding out the probability of achievement, and it is dependent upon and conditioned by an adequate supply of trained research workers in industry itself as well as in the research laboratory.

NUCLEAR ENERGY FOR AIRCRAFT

THE immensely difficult project of developing a nuclear reactor for aircraft propulsion was the theme of a recent talk at a meeting of the Chicago section of the Institute of Aeronautical Sciences. The speaker, Mr. M. C. Leverett, was well qualified for the task as he is connected with the General Electric Company of America which holds a government contract for building such a reactor, to be incorporated in due course in an airframe under construction by the Consolidated Vultee Aircraft Corporation. (A somewhat similar contract has since been placed with the Boeing, and Pratt and Whitney firms.) Such an aircraft must needs be a really big one since the radiation shield it has to carry may alone weigh anything between 50 to 100 tons. But, as Mr. Leverett points out, the fuel weight would be negligible compared with the 75 tons or more often carried in large modern aircraft; in fact, it has been estimated that, using fissile uranium, an American "B36" could fly 2 million miles on a single pound of this fuel! This means, however, that the landing weight, even at the end of the longest flight, will be just about as high as it was at take-off, and since there will be no appreciable fuel load to jettison, however convenient it might be to lessen weight, a long landing run is inevitable. This is a pity. On the other hand, with so tiny a rate of fuel consumption there would be no need to regard high thermal economy as so essential as to compel one to refuse any desirable change in reactor operation which could be gained by some sacrifice of thermal economy. The useful operational advantage of any aircraft propelled by nuclear fuel is its ability to fly almost unlimited distances

without refuelling, and even, in appropriate latitudes, of maintaining flight in continuous daylight, or entirely in the dark if preferred, and still have fuel enough at all times to bring it home by any route that might be preferred.

For practical reasons, it would certainly be convenient if the energy produced by nuclear fission arrived directly in the form of electric power; perhaps some day this will be achieved, but at the present time the energy appears in the form of heat, and a heat engine has to be used to transform this into the mechanical power we want. Security regulations prevent any publicity being given to the choice between the several forms of heat engine that might be used to create the propulsive effort this experimental aircraft will require. Possible kinds of reactor are a good deal less numerous, but one property they must have, and that is the ability—which must be quite unfailing—to control the rate of nuclear reaction, not so much to avoid the risk that the reactor might suddenly convert itself into a low-grade explosive bomb, as to avoid the risk of any overheating which might lead to the warping of parts of the mechanism, or in the limit to the danger of approaching their melting points. Mr. Leverett makes it clear that some of the most formidable of the difficulties to be overcome relate to the change in the qualities of the materials of construction which have perforce to endure the long periods of radio-active bombardment inevitable in the working of the plant. The effects of this are almost always detrimental; they may lead to a decrease in thermal conductivity so making the heat removal task even harder than it would normally be, or to a lowering of tensile strength, with an increase in brittleness and even an impairment in the insulating qualities of the electrical materials employed. It is found that the use of a brazing alloy containing but a few per cent of boron (a ready absorber of neutrons) may prevent steady operation in the reactor altogether.

The objective of this endeavour is admittedly ambitious; it needs to be so if justification is to be found for the use of substances in such high demand for other purposes as are uranium, plutonium or even thorium. Mr. Leverett concluded by expressing the belief that the task of enabling an aircraft to be built which will fly on nuclear power will meet with success. Together, the inherent difficulty of the undertaking, on the one hand, and the desirability and attractiveness of the objective on the other, combine to form a challenge to engineers which in many respects is almost unmatched.

Literature

Your Factory and the Law. By FRANCIS W. HUNT, B.Sc. London: The Sevenoaks Press, Ltd., 165, Victoria Street, S.W.1. Price 15s.

THIS book is designed to give an account of the Factories Acts, 1937 and 1948—an account which can be more easily followed by the ordinary reader than those which are to be found in the standard law books. Related provisions of the Acts have been grouped together so as to give as clear a picture as possible of what they require in the matter under discussion. Within the limits of a small volume the author would have found it impossible to deal with all the orders, regulations, exemptions, &c., in force or made under the Acts. One comprehensive book on factory law contains no less than 350 pages, setting forth nothing but regulations. And the cry is: "Still they come!" Mr. Hunt, however, summarises many important regulations and gives the numbers of all the factory "forms." He also provides the reader with lists of all the numerous pamphlets and publications issued by the Factory Department, together with particulars to enable them to be easily procured.

Everyone who essays to write on factory law is confronted at the very outset with one difficult question: "What is a factory?" So elaborate is the definition given in the Act of 1937 that there might almost have been a saving of printers' ink if the legislature had been content to say what is not a factory. In one instance those who drafted the Act went even better—they had recourse to the double negative. In Sec. 151 (9) we find that "any premises belonging to or in the occupation of the Crown or any other public authority shall *not* be deemed *not* to be a factory . . ." Mr. Hunt points out (on page 3 of his book) that it is laid down in Sec. 103 of the Act of 1937 that whereas the making of any article on "premises" constitutes them a factory, the legislature were at pains to point out that electricity *for the purpose of that section* shall "not be deemed to be an article." The draughtsman only mentioned something that electricity is *not*; he did not presume to tell us what it is!

Mr. Hunt has not attempted to write a legal text-book replete with references to, and extracts from, decided cases. Some citations from judgments of the court there are, of course; but it was obviously not the intention of the author to write a treatise which learned counsel would consult when asked to write an "opinion" on a complicated question. For instance, having set forth (on pages 1 to 4) the definition of what the word "factory" means when used in the Factories Acts, our author quotes from no judgment. But he does something very useful; he emphasises the outstanding importance of certain words used in the statutory definition. For instance, the word "factory" (in certain cases) includes any "premises in which *mechanical power* is used in connection with the making or repairing of articles of metal or wood incidental to any business carried on by way of trade or for purposes of gain." If a grocer has a workshop in which to effect everyday repairs, he might be the possessor of a foot-lathe without being exposed to the liabilities of the owner of a factory.

The importance attaching to every word of the definition was emphasised in a recent case (Joyce *v.* Boots Cash Chemists (1950), 2 All E.R. 719), where it was sought to make the owners of a retail shop liable as owners of a factory. A porter whose job it was to load and unload vans and to weigh out commodities for sale sustained an accident. He slipped when carrying a parcel. It was held that as his employment did not relate to "the making of any article or part of any article," his employers were not, in fact, the proprietors of a factory.

Prevention of industrial accidents having been for over a century one of the basic aims of factory legislation, due attention is paid to this important matter in Cap. IX. To the question: "What is dangerous machinery?" Lord Cooper, then Lord Justice Clerk, gave a reply which is quoted on page 55 of this book. He said: "The test is objective and impersonal. Is the part such in its character and so circumstanced in its position, exposure, method of operation, and the like that, in the ordinary course of human affairs, danger may reasonably be anticipated from its use unfenced, not only to the prudent, alert and skilful operative intent upon his task, but also to the careless or inattentive worker, whose inadvertent or indolent conduct may expose him to risk of injury or death from the unguarded part?"

Stress is also laid (in Cap. XI) on "safe means of access." If an accident occurs as a result of failure to provide and maintain safe means of access, the factory-owner is not only liable to pay a penalty but may have to pay damages. Although, broadly speaking, every workman who sustains injury in the course of his employment can make a claim under the National Insurance (Personal Injuries) Act, he can also bring an action against his employer—an action which will succeed if negligence is proved. And where there has been a breach of a regulation laid down in the Factory Act, negligence is presumed. The wide meaning which may attach to the words "means of access" and the word "safe" was emphasised in a recent case. An electrician had to use a 10ft ladder to get to his job. He placed it at the proper angle on a floor which was "semi-glazed," a fact which was obvious to everyone. The ladder slipped and the man was injured. A judge of the High Court in these circumstances held that the factory-owner had not provided "safe means of access"—being of opinion, apparently, that an adult workman must be looked after in every detail of his work as if he had no more sense than a child.

On page 77 of this book Mr. Hunt, commenting on "safe means of access," says, very properly, that "should ladders be used they must be soundly constructed and properly maintained." How, in the name of common sense, can the owner of a factory be asked to do more? And yet, in the case we have mentioned, the employer was mulcted in damages to the tune of £1250!

A good index completes a work which should prove very useful to those who have to grope their way through the mazes of the Factory Acts.

The Manufacture of Iron and Steel: Vol. II, "Steel Production." By G. REGINALD BASHFORTH, F.I.M. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 45s.

IN this book the basic principles underlying the various processes of steel-making, and the plant and equipment employed are surveyed to "provide a suitable textbook for the general student of metallurgy and . . . . a handy reference book for the busy industrialist." This aim is stated in the author's preface, and as melting-shop manager at Round Oak Steel Works, Mr. Bashforth is admirably placed to fulfill it. He has provided a most useful handbook based on British practice, the most comprehensive to be written by a practical steel-maker in this country.

The arrangement of the book is logical

and straightforward, with an index which adopts the sensible notion of printing the main entry for each subject in bolder type than the other, passing entries. The references are grouped after each chapter, but here lax proof-reading has introduced some irritating errors, as in the references at the end of Chapter VI and in those at the end of Chapter XIV.

The Bessemer and open-hearth furnace methods of steel-making are dealt with successively at the beginning of the book, each section starting with a chapter on general principles and plant layout. Particular aspects such as basic and acid practice, fuels, and furnace construction are then dealt with in separate chapters. Electric furnaces are dealt with in a single chapter, followed by chapters on ingots, side-blown converters, modified processes and one on the older methods of cementation and crucibles, the former, since October, 1951, extinct. Lastly, there are chapters on instrumentation, special steels (in which he pays special attention to grain size control), and refractories. This arrangement legitimately sacrifices a strict historical order in favour of lucidity and easy reference.

The author sets himself a high standard of accuracy and comprehensiveness, and the very extent to which he reaches it poses a problem which publishers must set themselves to answer if full value is to be obtained from reference books such as this. This book is "first published in 1951," and in fact appeared near the end of that year. The Author's preface is dated June, 1949, and there is in the book no reference to published material later than September, 1948, save an isolated reference to a book published early in 1949. This book, therefore, seems to have taken nearly three years to produce after the manuscript was completed. There appears to have been no attempt to bring the contents up to date in the interim and the book suffers in consequence. The manager of an electric melting shop, for example, would find here no mention of even the possibility of using the oxygen lance for rapid carbon elimination, though this has become routine practice in certain British works, and was described in THE ENGINEER for June 13, 1950. Similarly, the open-hearth manager interested in building furnace roofs of basic bricks will find a note on basic bricks (though no mention of the part played by sea-water magnesia in their development in this country) with the correct statement that they seem to offer certain advantages, but that their economics have still be to assessed. He will, however, find no practical examples, and the only two references date to 1940 and 1941, respectively, although two post-war British all-basic furnaces went into service in November, 1948, and five had actually completed campaigns by the beginning of 1950. One does not wish to minimise the difficulties under which book publishers labour at the present time, but it does seem that the delays imposed upon them sometimes offer a challenge which is not accepted.

Mr. Bashforth has been ill-served by his publishers in another respect. The purchaser of a book at 45 shillings, even at present prices, is entitled to expect a better standard of illustration reproduction. Many are distractingly fuzzy, as, for example, Figs. 37, 42, and 211, while Fig. 41 is so unrealistic that it reminds one of a Disney cartoon rather than a steelworks. The many drawings, on the other hand, are a delight of clarity and elegance.

It is only too easy to criticise. The higher the standard an author and his publisher set themselves, the easier it is for the spectator to detail dreary lists of particulars in which they have fallen short. It should be re-emphasised that this book is a most welcome publication, which will prove invaluable to students and to the steel-plant managers and workers of this country.

The Steam Locomotive of To-day. By M. P. SELLS, O.B.E., M.I.Mech.E., M.I.Loco.E. London: The Locomotive Publishing Company, Ltd., 88, Horseferry Road, S.W.1. Price 10s.

AT a time when the usage of steam locomotives is tending to become ever more intensive there is an urgent need for greater understanding of the machine by all concerned in its servicing, repair, and its operation. Part of Major Sells's book was originally written in 1934 for the African running staff of the Nigerian Government Railway; it has now been revised, greatly enlarged and rendered of more general application. Modestly the author calls it "a little book," but its 244 pages are packed with just that information that is invaluable to those who have the care and running of steam locomotives. A minimum of space is devoted to theory and practically nothing to considerations of design.

Major Sells describes the principal parts of the locomotive, boiler, front end, and the development of tractive effort, and proceeds to deal one by one with the fittings—boiler mountings, brakes, lubricators, and so on—in very complete detail. Some of his more interesting chapters deal with failures and their prevention, with the duties of drivers and firemen, and with some aspects of workshop practice. He stresses the need for complete co-operation between drivers and running shed staff in the booking of defects and the application of remedies: to the lack of this co-operation may be attributed perhaps many of the locomotive operating troubles on British Railways to-day! So far as firing practice is concerned, he writes naturally from his own experience on the Nigerian and Rhodesian Railways, and his precise instructions would not be readily applicable everywhere, particularly where soft Welsh coals are in use.

The book is finely produced and well illustrated, with a wealth of first-class drawings, and can be strongly recommended.

Electromagnetic Waves and Radiating Systems. By E. C. JORDAN. London: Constable and Co., Ltd., 10, Orange Street, W.C.2. Price 32s. 6d.

IT is only just over a decade ago that a knowledge and understanding of Maxwell's Equations and the Theory of Radiation were confined to the physicist and mathematician, or the specialist communications engineer. With the rapid growth in technical development and widespread use of electromagnetic waves in radar, television and telecommunications, during and since the war, more and more electrical engineers are concerned with the fundamentals involved. There have been of late a number of books published on the subject and the engineer must examine each one carefully to see whether it meets his particular requirements. Professor Jordan has written a book in the Prentice-Hall Electrical Engineering Series, based on his experience in teaching electrical engineering at the Ohio State University and the University of Illinois, which provides both a comprehensive treatment of the fundamental theory of electromagnetic waves and radiating systems and, for the specialist, a more advanced part on aerial theory and propagation.

In the first chapter on the fundamentals of electromagnetic engineering, vector analysis is introduced with a simple physical interpretation of the vector operators and a straightforward derivation of the essential equations in the necessary co-ordinate systems. There follows a discussion on units and dimensions with an account of the rationalised M.K.S. system, which is used throughout the book. All the electrical quantities are then defined with their units and dimensions, and (much appreciated by the practical engineer), a note on the order of magnitude of various units.

The purpose of the next two chapters on electrostatics and the steady magnetic field is clearly given by the author as "(1) to review the subject briefly, not as a study in itself, but as an introduction to the electromagnetic field; (2) to consider the statement of the laws in the vector form, and, finally, (3) to state the required relations in the M.K.S. system of units." The treatment in these chapters is thorough and includes solutions of Laplace's Equation with applications to practical problems. Maxwell's Equations logically follow, and their solution in a homogeneous medium. The practical aspect is not lost sight of by a discussion on conductors and dielectrics and the electrical properties of the earth. Reflection and refraction are then considered, leading up to a step-by-step analogy between the solution of the transmission line equations and those of a uniform plane electromagnetic wave and the concept of characteristic or intrinsic impedance of a medium. Complex notation, familiar to the power engineer, is used in the treatment of the Poynting Vector and flow of power, which form the subject of the next chapter.

A chapter on guided waves, which includes a rigorous solution of Maxwell's Equations for a wave travelling along the surface of a conductor, precedes two chapters on transmission lines and wave guides. In the former are introduced practical applications such as stub matching, use of circle diagrams and data on types of u.h.f. transmission lines. Radiation which follows is dealt with by the usual method of retarded potentials leading up to the half wave dipole with assumed sinusoidal current distribution, and the determination of its radiation resistance, both by graphical integration and expansion as a series. A statement of network theorems and a discussion of their application to aerials concludes the chapter. These first ten chapters, with 341 out of a total of 688 pages, thus occupy the first half of the book.

The second half contains more advanced subject matter on aerial theory and propagation. Directional characteristics and impedance characteristics of aerials are considered theoretically, although a chapter is included on practice and design. Babinet's principle and Fresnel's diffraction are used in the last aerial chapter dealing with radiation from slots and horns. The book is enhanced in value by the inclusion of the last two chapters on ground wave propagation and sky wave propagation. These subjects are normally afforded a general qualitative mention. Whilst retaining a practical viewpoint, Professor Jordan has made use of theory already covered in his book to give useful quantitative treatments. Norton's expression for the field due to a dipole above the surface of the earth forms the basis of the ground wave analysis. In the sky wave analysis the effects of the earth's magnetic field is considered and the theory underlying the preparation of and use of maximum usable frequency curves is given.

There are two appendices. The first explains phase and group velocities; the second gives a brief explanation of Bessel functions with a collection of useful relations and formulæ. Finally, there is a complete alphabetical list of the symbols in the book. Symbols are frequently a source of confusion and irritation, but in this book they have been chosen with skill and care so as to present no difficulties in spite of the wide range covered. Over 130 problems are included among the text or at the end of each chapter. The method of solution is sometimes suggested and, where appropriate, answers are given. A bibliography is also given at the end of each chapter. As would be expected, a large number of the references are to American publications, although important British contributions in books and publications, such as the *Journal of the Institution of Electrical Engineers* and *Wireless Engineer* are included, and some German papers are referred to.

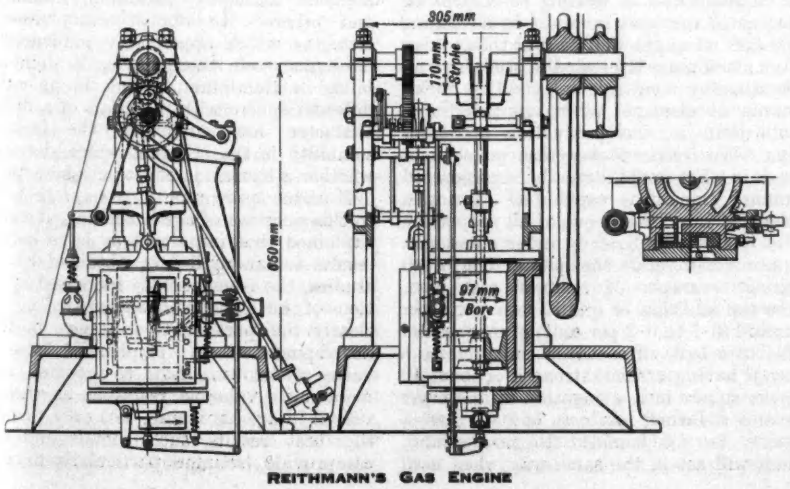
The book is very comprehensive, and the basic theory of a wide range of subjects has been given. Wave guides have possibly not been dealt with as fully as other subjects. There is no mention of cavity resonators or indication of wave guide measurement. The author is to be commended on the lucidity of his work. The adoption of a logical sequence, the inclusion of analogies and alternative treatments, the use of examples, all serve to produce a very readable book on a far from easy subject. The treatment throughout is of necessity largely mathematical. But the mathematical analysis has been handled elegantly with accompanying clear explanation and the equations are well set out with a good system of numbering. It is apparent that great care has been taken in the preparation of the book, which is singularly free from errors. The diagrams are clear, and the layout and production are of high standard. It is recommended both as a text book for the honours degree student in electrical engineering and as a valuable reference book for the communications engineer interested in the fundamental theory of his subject.

A Gas Engine Centenary

(Contributed)

THE years 1850–1859 are of much interest to the student of technology. In 1850 the Brothers Brett laid the first submarine cable. During 1851 Joule proposed his constant pressure cycle without heat regenerator. In the United States Ericsson (in 1852) constructed his hot air engine for propelling the "Ericsson," a bold experiment which did not succeed. In 1854 Barsanti and Matteucci patented their free-piston atmospheric gas engine, afterwards developed by Otto and Langen. Charles Parsons and Dugald Clerk were born in 1854 and during the same year Clausius published his important paper, "Ueber eine veränderte Form des zweiten Hauptsatzes der mechanischen Wärmetheorie." In 1855 Drake introduced (in America) the hot tube ignition and the method of explosion starting for gas engines. A year later Perkin described the first aniline dye, thus laying the foundation of the coal-tar dyeing industry. In the same year, 1856, (if the editor will permit mention of it), there appeared, on January 4th, the first issue of THE ENGINEER. During 1857 James Robson commenced the construction of a two-cycle atmospheric gas engine, in which there was a working stroke at each revolution of the crankshaft, make-and-break electric ignition being used. In 1858 Henri Giffard patented the injector and John Fowler introduced the steam plough.

It was in the early part of this momentous decade that Christian Reithmann, court watchmaker at Munich, constructed (during 1852) a gas engine which has an important place in the history of prime movers. Reithmann used a mixture of air and hydrogen gas ignited by spark from a battery, and he employed the engine for driving the machinery in his workshop. The technical significance of this century-old machine lies chiefly in its subsequent history, since by modifications effected between 1872 and 1873 the old watchmaker so altered his engine as to make it operate on the four-stroke cycle. The extreme probability is that this was the first working machine to employ the cycle proposed some ten years earlier (in 1862) by Beau de Rochas, and it is recorded that Professor von Linde saw Reithmann's engine operating in its four-stroke form during 1872. The watchmaker's engine was cited during the litigation in 1884 on the subject of Otto's German patent (No. 532 of June 5, 1876). On the occasion of this litigation the Provincial Court at Munich recognised the priority of Reithmann over Otto, though an appeal from this decision by Deutzmotorenfabrik was upheld by the Upper Court. Prior to this appeal, however, Deutzmotorenfabrik had purchased Reithmann's engine, together with any rights of prior use which might be based on it. The watchmaker did not press his interest and thus he is remembered not as a patentee but as a prescient pioneer entitled to an honourable position among early designers of internal combustion engines. As was remarked by Dr. Arnold Langen, "Reithmann, dem unermüdlichen Grübler, gebührt die grösste Achtung." Reithmann's engine was of the single-cylinder, vertical type, with superimposed crankshaft, the bore being 97mm, stroke 110mm. Crosshead construction was used, and in the final arrangement of the engine there was a toothed-wheel gearing of ratio 2 : 1, the machine being single-acting, whereas, in its first form, double-acting operation was employed. The engine is believed to have remained in regular service at Munich until 1881, the illustration herewith showing Reithmann's engine in the four-cycle form which it attained about 1872, four years prior to the application for Otto's patent.



REITHMANN'S GAS ENGINE

The mechanical ingenuity of Reithmann is a reminder of the notable contributions made to engineering science—and thus to civilisation—by watchmakers. We shall remember, for example, the genius of Robert Hooke, who, though not a watchmaker by trade, contrived (1658) the spiral balance spring and collaborated with Thomas Tompion in making that famous watch which was presented to Charles II in 1675. Tompion, the father of English watch and clock-making, was honoured by burial in Westminster Abbey and thus not only worked for Kings but sleeps among them. We may think also of Jean de Hautefeuille, that learned ecclesiastic and mechanic, who, independently of Hooke and some years after him, proposed the spiral balance spring. Huygens was also an independent discoverer (in 1675) of the spiral balance spring. Unique perhaps among watchmakers, was Beaumarchais the dramatist, who, like Christian Reithmann in Munich, was at one time court watchmaker in Paris and made watches for Louis XIV and Madame de Pompadour. He also invented—in or about 1753—a new escapement for watches. Beaumarchais went from watches to literature and when we read of the protracted litigation which attended the development of the four-cycle engine and of the criticism and adulation which has been uttered in respect of the various inventors and patentees, we do well to recall the words of Beaumarchais in that place where he warns us that "Sans la liberté de Blâmer, il n'est pas d'éloge flatteur!" It is surely possible to praise the craftsmanship and tenacity of the Munich watchmaker, whose labours, a century ago, won him a secure place in the history of the internal combustion engine.

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Metals and Alloys of To-day and To-morrow

By H. W. GREENWOOD*

The production of magnesium is expected to rise to 150,000 tons per year by 1960. That of titanium is likely to increase very rapidly to as much as 7000 tons next year. These increases are symptomatic of a rapid increase in the variety of materials available to engineers and of a large improvement in the metallurgists' knowledge of the whole gamut of metals used in industry. There is greater realisation to-day of the important effect of impurities in causing or controlling reactions of the kind involved in hardening processes. The importance of using purer metals commercially and industrially is thus emphasised. Further references to titanium alloys and to powder metallurgy, infiltration and the use of coated powders complete the author's survey.

DURING the last year or two engineers have realised that major changes were occurring in the supply, the qualities and the properties of the metals upon which they relied for both constructional materials on a large scale and for parts of all sizes. One principal factor has been the rearmament programme, which resulted in the increasing scarcity of most of what might be called the rarer metals. This naturally stimulated investigation into possible substitutes. There has been also the constant pressure to increase working temperatures both in static and in moving machines. There has been what might almost be termed the flight from the reciprocating engine to the turbine, and onward to the jet; each of these factors has had an effect and the cumulative result has been to accelerate progress in the introduction and application of new materials to an extent that is almost embarrassing to the engineer who attempts to keep touch with what is happening, and desires to have and to use the latest and most suitable material for his particular purpose. In this he is not actuated by desire for mere novelty, but is aware that modern materials can offer physical properties of outstanding appeal and that not only now, but increasingly in the near future, the newer materials will be a necessity if only because of the greater demands that will be made upon them and the severer conditions of service they will have to sustain.

An outstanding phenomenon in the modern evolution of metals has been the march toward lighter metals in almost every sphere wherein metals play a part. It has come as a surprise to find that the U.S.A. is short of aluminium, notwithstanding that her production of that metal is expected to reach over a million tons this year and one and a half million tons next year, while Canada will produce three-quarters of a million tons next year and can help the U.S.A. with 50,000 tons this year. Magnesium, an important light metal, is expected to reach a production of 50,000 tons per annum in U.S.A., increasing to 150,000 tons per annum by 1960. Another surprise is titanium, which until recently was little heard of except for the coating of certain electrodes, and the production of titanium white. Now the metal is expected to arrive at an output of eight million pounds in 1952 and double that for next year, an increase in two years from approximately 470 tons to 7000 tons a year. Many other figures could be quoted to show the rate of change that is taking place, but there is much more behind it than mere increase in production. For some years now we have been witnessing a revolution in the nature and properties of metals and alloys being made available to engineers and constructors and although we have just written of the light metals and of a semi-light metal, titanium, the revolution has embraced the whole gamut of metals and alloys used in industry, commencing with cast iron and including almost every metal and alloy with which the engineer is familiar. Parallel with this development and evolution there has been the appearance and increasing application of materials which have perhaps nearer affinities with ceramics. The outstanding example here is the carbides, which, from being used as cutting materials because of their hardness, are now widely employed as refractory bodies and as anti-abrasive and corrosion-resisting materials that may even appear as turbine blades.

Notwithstanding the notable developments in this domain, it is safe to say that the future will see more and wider applications made and that combinations of metal and carbide will offer many possibilities of solving problems as yet not envisaged.

* Powder Metallurgy Limited, London.

Age Hardening and Impurities

A vast field awaits development in the realm of metals and alloys capable of age hardening. Although we have known of duralumin since about 1907, we are only now beginning to realise how great are the potentialities of age and precipitation hardening, and only in the last few years has the mechanism of the reaction been clearly explained and understood. Having used the process of heat-treatment empirically, we are now moving toward control of a different order to any hitherto envisaged, and such work includes metals and alloys that so far have not played a large part as heat-treatable metals. New techniques in allied fields, such as powder metallurgy, also hold out great promise of producing materials whose physical properties will be notably ahead of anything that has been attainable hitherto.

An interesting facet of modern progress in the study of metals and alloys is the importance of impurities in causing or controlling reactions of the kind involved in hardening processes. It might well be said that to-day we are much more interested in studying and understanding the role played by small amounts of elements acting as interfering agents than in the production of major alloys. We realise to-day that an element present in what would normally be considered a minute amount is capable of causing a measure of interference out of all proportion to its quantity judged by older standards. Engineers will recall the outstanding, even amazing, example of nodular cast iron, where the addition of one to two parts per thousand (0·1 to 0·2 per cent) of magnesium added to a ladle of cast iron can produce a material having a tensile strength of about 40 tons per square inch, elongation up to 16 per cent and a Brinell hardness of 200. Such a property is not confined to magnesium; cerium will act in the same way when used in the same proportions, but not every element acts in this way. As engineers to-day are well aware metallurgists are realising more and more the importance of the atomic structure of their metals and particularly the form and physical behaviour of the crystal lattice of the metals and alloys they are studying. It is here that the importance of extra elements in the hardening or varying other physical characteristics is seen, for such an element may interfere with another that is playing the part of a hardener. Its interference may prevent the diffusion of the hardening agent, which is attempting to get out of a solid solution and so produce what we know as precipitation hardening. Certain elements can completely inhibit such a process. It may be that another element may have the opposite effect, in that it can provide centres of and for precipitation and so facilitate hardening. In this case size is of importance, for it can cause either contraction or expansion of the crystal lattice of the main solid solution. Hence an important role can be played by a third element, the addition of which can increase the strength of the fully age-hardened alloy. There is one thought behind all this work. It is not the elucidation of the various processes, important though that is. It is the accession of accurate knowledge that will enable the exercise of the most exact control. It is already manifest that much that appeared inexplicable and mysterious in the behaviour of metals and alloys in the past was probably the result of the presence of quite small amounts of elements which played a dominant part in determining their properties. We are already in possession of numerous authentic examples of the power of minute quantities of one element to alter entirely some particular property or even perhaps a whole series of properties. One case may be cited: it is the addition of a few hundredths of 1 per cent of sulphur to the cast metal of the permalloy type used in audio frequency cores. The sulphur coats the grains of metal so that the metal can be hot rolled to produce a fine equiaxed grain structure which at room temperature is so brittle that it can easily be ground to powder. Even more striking effects have been published, and it is not surprising that much research work has been planned, and in part carried out in investigating the effects of small amounts of elements especially on the ageing characteristic of both cast and heat-treated aluminium-copper and aluminium-copper-titanium alloys. The additions made in the case of one important series of researches carried out in this country have been of the order of 0·05 to 0·1 per cent and the elements have included antimony, cadmium, indium, tin and others. In almost every case the elements which appreciably influenced age hardening were those having a slight solubility in aluminium. Work in an entirely different sphere with materials of a different character has confirmed the fact that solubility is the criterion which determines whether a hardening effect may be expected.

If undue space appears to have been given to this question of age-hardening, it must be explained that important as have been the results so far applied or obtained by these studies, the tremendously increased applications of the light metals anticipated indicates clearly the part they will play in future development. It emphasises also the value of knowing how to control effectively such valuable reactions as those involved in age-hardening, not only to obtain the best results such metals and alloys can provide, but more particularly to control

the economic aspects of the processes by accelerating the onset of the reaction and shortening the time required for full ageing.

An effect of all this work that has not been mentioned is the emphasis on the importance of using pure metals in commercial and industrial applications. That is, indeed, one of the problems of the future, because the purity envisaged is of a very different order to that thought adequate only a year or so ago. We know there are metals that can be supplied of 99·9999 per cent purity and that commercial metal of 99·99 per cent is commonplace. We have to think of comparable purities for quite a number of commercial metals in the near future and we may discover that many properties we thought of as appertaining to this or that metallic element were due to its impurities and not to the element *per se*.

The present-day concentration on the production of metals and alloys capable of withstanding high temperature, and particularly resistance to creep, is naturally a special aspect of the question of purity. This aspect was emphasised some years ago by Sir William T. Griffith when he said that not only minute variations in composition, processing and treatment affected creep resistance, but the presence or absence of as little as 0·001 per cent of a single constituent or a change of 0·1 per cent in the content of another may make all the difference in high temperature properties. In this connection it may be of interest to mention the valuable investigations being carried out at the Fulmer Research Institute by Dr. H. K. Hardy and to quote from some results as illustrating the control factor and the magnitude of the effects caused by what are in fact quite small additions of other elements. The experiments were made with materials of the highest available purity. The alloy for age hardening was aluminium-copper-titanium and the particular result to be mentioned here was the effect of adding 0·05 per cent cadmium—that is, one part per two thousand—and may be taken as fairly typical of the effect of these addition agents. The alloy without addition of cadmium reached its peak 0·01 per cent proof stress of 16 tons per square inch only after six days at 165 deg. Cent. When 0·05 per cent cadmium was present 0·1 per cent proof stress reached the value of 21 tons per square inch after about forty hours at 165 deg. Cent. In general character these English investigations can be paralleled by work in the United States on the effect of ternary additions on the age-hardening of a copper-silver alloy. Although this experimental work is not as yet complete, the results, both in this country and in America, point clearly to the means of attaining better and more closely controlled properties for the most important group of age-hardening light metal alloys.

Titanium as a semi-light metal is of interest in the field of high temperature resistant alloys, but as yet results can be classed only as encouraging to further investigation. From U.S.A. come reports of an alloy with 92 per cent titanium, 5 per cent chromium and 3 per cent aluminium, which is said to be as strong as high-strength steel, highly resistant to corrosion and capable of standing high temperature yet only half the weight of steel. This is an alloy developed by the U.S. Navy Bureau of Aeronautics and is suggested for use in constructing jet aircraft and engines. It is said to find application at present for turbine blades, firebox walls and other components. It reminds us of the importance of the weight factor and the desirability of using, if at all possible, components much lighter than those at present available. This is not only a matter of reducing deadweight, but also of materially reducing such factors as centrifugal stress in running and allowing of a worthwhile reduction in power. It is suggested that a weight saving of as much as 300 lb could be accomplished per engine, with all its accompanying benefits. One of the potential aids to producing specially light materials is the application of infiltration of porous metal or similar materials. This procedure has already received practical application by the production of over a million turbo-compressor blades by infiltrating a sintered iron mass with a copper alloy capable of precipitation hardening. A field offering even more desirable promise is that of the infiltrating of tungsten and tungsten-chromium skeletons, produced by powder metallurgy technique with nickel or cobalt-based alloys of the nichrome, vitallium or hastelloy type. Experimental studies have shown that such infiltration is perfectly feasible and can be carried out either by capillary action or under vacuum conditions.

A procedure which has certain affinities with infiltration methods is the use of coated powders. It has been found that many hard brittle powders such as cast iron can be coated with a comparatively thin layer of a softer metal, such as copper, tin or nickel, and then pressed in the usual powder metallurgy manner when they produce pressings of good green strength and after sintering at 980 deg. to 1000 deg. Cent. in a slightly reducing atmosphere provide easily machinable components of good strength. A variation of the procedure is to use mixtures of oxide of copper and lead. In all these cases the coating plays much the same part as an infiltrating metal in a porous pressing and it has the advantage that upwards of 80 per cent of the material can be of the cheapest metal available. Incidentally, it also allows of the pressing of such powders as cast iron with comparatively low pressures and eliminates the major part of the die wear usually met with when pressing powders like cast iron.

Powder Metallurgy

Powder metallurgy has been mentioned several times and has some additional services to render in producing new metals and alloys. It has long been known that what might be termed classical metallurgy—that is, those procedures which involve the melting and casting of metals, had certain disadvantages and some very definite limitations. To begin with, one very large limitation is the fact that one can only deal with those phases of metal or alloy which can separate from a molten mass. It is quite impossible, for example, to produce by melting and cooling combinations of two metals having very divergent melting points. But such combinations are quite feasible by powder metallurgy because the melting point of the higher melting component never need be approached. Again, it is not possible by other than a powder metallurgical technique to obtain infiltrated bodies which to-day are a commonplace. Then there is the very wide range of highly refractory materials, such as carbides, oxides, and the like, which offer obvious possibilities if combined with or infiltrated by metals. Another field only possible by powder metallurgy is that of porous bodies in which the porosity is closely controlled, not only as to total porosity, but also as to the dimension of the individual pores. In this direction there are the various components that might be sweat-cooled as well as other units of service in chemical engineering by which one can safely mix gases, liquids, filter under considerable pressure, &c. Another comparatively recent development with metal powders is their use in the production of extruded metal used mainly in the production of small parts. A notable example is the production of a comparatively wide range of magnesium alloys starting from fine powders of magnesium and other metals in powder form and, after mixing, extruding the alloy by a hot extruding process. It is claimed that this method gives greater strength and also ranges of compositions impossible to obtain by casting. This technique has led to the coining of a new term in metallurgy, namely, "interference hardening." It is applied to the effect produced when combinations are used which are possible by powder metallurgy, but prohibited by the phase rule and which are obtained by mixing powders so as to bring about increased precipitation and concurrently greater hardening or, as can happen in certain cases, the formation of heat-insoluble precipitates. An example can be mentioned. Aluminium is normally undesirable in cast magnesium-zirconium alloys because of its affinity for zirconium. If, however, the aluminium is added as powder to magnesium-zirconium powder and the alloy formed by extrusion of the mixed powders, then the precipitation of the aluminium-zirconium compound will give a strengthening effect similar to that brought about by age-hardening. This effect has been observed both in the case of magnesium-zirconium and magnesium-zirconium-cerium alloys to which the aluminium was added in the form of powdered magnesium-aluminium eutectic. Appertaining to the sphere of heat-resisting materials there are the carbides, which alone, mixed or infiltrated with other materials mainly metallic, are being widely experimented with. There are also the many possibilities of utilising ceramic materials again either alone or associated with metals in the form of the so-called cermets or ceramals. This subject could well provide a large chapter if its achievements and especially its potentialities were to receive the treatment they merit. It may suffice for the moment to mention the infiltration of sintered iron parts with a molten ceramic enamel, which acts as a completely protective coat against oxidation or other corrosive attack; there is also the coating of stainless steel sheet and parts with a thin ceramic slip, which has had successful application in chemical engineering. Attempts have even been made to cast turbine blades by slip casting the tip portion in ceramic capable of resisting severe thermal shock, while the base section or root is cast in ceramic having high mechanical strength. Some of the combinations are so novel that they promise wholly unexpected solutions to problems in both chemical and general engineering, as well as outstanding contributions to the conquest of many difficulties in reaching higher efficiency in jet and turbine engines. The whole picture is extraordinary if only because of its wide divergence from the conventional metallurgy of only a few years ago.

Overseas Science Students' Association.—At a meeting held recently in London, an Overseas Science Students' Association was formally instituted under the presidency of Mr. W. J. De Coursey. Its objects are to bring graduate science students from overseas into contact with the scientific life of Great Britain and to bring such students into contact with one another. The Association is affiliated to the Society for Visiting Scientists. About 100 overseas science students have already joined and further applications are invited. They should be addressed to the secretary of the Association, Mr. P. Sen, care of the Society for Visiting Scientists, 5, Old Burlington Street, London, W.1.

The Institution of Naval Architects

ANNUAL SPRING MEETING

No. II—(*Continued from page 501, April 11th*)

THE meeting on Thursday morning, April 3rd, opened with a paper entitled :

MERCHANT SHIP DESIGN : A THOUGHT FOR THE FUTURE

By Sir Wilfrid Ayre

Summary

Thought for the future demands the attention of ship and marine engine designers if the changes in the requirements of sea transport are to be met and progress made against the forces of expediency, complacency and obstruction. The immediate factors affecting ship design are presented as a family tree and the items are discussed in the paper. Design will be affected by changes in economic standards and by such factors as bulk buying and currency restrictions and the virtual disappearance of coal as an export also will have its effect on tramp shipping. Raw materials have caused the production of specialist ships and in general sea speed will continue to increase. For cargo handling, winches and derricks must disappear eventually and the mechanisation of the handling system is a "must" for ships carrying bulk cargo. The type of machinery will be influenced by the trend of sea speed and the need for unobstructed cargo spaces will decide its position. Aluminium alloys will be a major shipbuilding material as soon as their advantages are proved and accepted.

Discussion

Mr. J. Lenaghan : A few years ago 10 knots was acceptable for tramps, to-day it is 12 to 15 knots, and ten years hence it may be 16 knots. The need for the dual-purpose ship has been stressed, and I would like a dual-speed ship, because of the introduction of the multi-diesel engine drive. I have in mind a tramp ship with four engines ; when freights are high it could use four engines, and when freights are low it could use two engines and less fuel.

Technical problems involved are the acceptance of a less efficient hull and less efficiency in the top speed range.

I am not happy about the future of the twelve-passenger ships ; they add considerably to costs, and in the future we shall want to travel more quickly.

The present arrangement for cargo handling on ships is possibly the cheapest form of handling equipment, to consider adding any other type of equipment is wrong, and it is a matter for the port authorities, rather than for the ship designers.

The machinery space placed aft is the thing for the cargo ship, and I do not know why it is not developed to a greater extent. I do not think a tank need be regarded as waste space ; nor do I think we want a forward bridge space.

Aids to navigation are improving and increasing in number, but there may be a blind spot from the bridge as we know it to-day.

I think funnels will disappear. Although space is valuable in ships, we are providing single rooms for all the crew on board, but there should be more centralisation, and why not have two large mess spaces, one for the officers and one for the crew?

Mr. J. D. Farmer : Concerning the freezing of fish at sea, attempts have been made to commercialise this process, but accommodation and handling difficulties have not made the process an economic proposition in this country.

In 1928 two ships were equipped with quick freezing apparatus for dealing with fish fed to them by small catchers. This attempt failed because the fish could not be marketed profitably in the required time, before the ships were due to sail again. The quick freezing of fish within hours of being caught provides the best possible quality, provided that the rest of the handling chain is laid out appropriately.

Fish must be cooled from catching temperature to about —5 deg. Fah. in about two hours, which means a large and expensive plant of the order of 120 h.p. per ton per hour for all purposes.

Air conditioning implies not only cooling but also the control of the moisture content.

In the carriage of perishable products little attempt has been made to control the moisture content of the air, but it is desirable to maintain the air as near saturation point as possible. For true comfort the lowering of the moisture content of the air is generally more important than the lowering of the temperature.

The two methods of carrying perishable fruits are by ventilation by fresh air through uninsulated holds by either natural draught or fans, or in insulated holds by refrigerated air circulated in a closed circuit.

With fruit, CO_2 and other gases are given off and it is necessary to inject a certain amount of fresh air in order to keep the concentration of undesirable impurities within permissible limits. Meat and other perishables carried at temperatures below freezing point do not give off any harmful gas and no injection of fresh air is needed.

Some fruit ships have been equipped with refrigeration operating on a closed air circuit in non-insulated holds. These are for special runs where the water and atmospheric temperatures fall from the time the ship sails in the loaded condition.

Professor E. V. Telfer : The idea of the 60,000-ton ship springs from the realisation on the part of some shipowners that it is possible to have a 60,000-ton merchant ship. The principal cause of ship change, so far as both speed and size are concerned, is socialisation.

I do not think the statement that the slow-speed ship could transport a greater aggregate of cargo in a given time than its speedier rival is true. A 10,000-ton ship of relatively low power, which could do 10 knots, was wallowing around the Atlantic at 7 knots, while ships designed for 12 knots were maintaining speeds averaging 11½ knots. Without any great change in design, those higher powered ships were transporting very much more cargo than the so-called low speed ships.

While it may have been possible in the early nineteen-thirties to have ships running at low speeds, it is not possible now for British shipowners to use that alternative economically, because socialisation pressure has prevented them reducing the wages of their crews in order to run economically at low speeds.

I agree that "deadweight or bulk carriers in the future, helped by still further research in model tank work, are likely to have much fuller forms, as conveniently expressed by block coefficient, than is current practice to-day." The real skill of the naval architect requires an improved ship with increased block coefficient and that is not impossible. The "Wilfrid Sykes" has a power of 7000 h.p. and a speed of 16 m.p.h. ; the block coefficient of that vessel running at that speed is no less than 0·875, and it is an extremely economical form, so that the Great Lakes are showing naval architects the way, and the attention of the experimental tanks is directed to a complete reversal of their present methods of designing.

Mr. J. M. Murray : I should like to call attention to a funnel which has found favour in France ; it is called the "Strombus" funnel, it is like an aeroplane wing on the deck, with a streamlined section, and it seems to serve very well.

With regard to the amount of cargo which can be transported by a fast ship as against a slow one, in a paper on petroleum tankers, read before the American Society of Marine Engineers and Architects in 1948, it was shown that for a voyage of 2000 miles a 16-knot ship transported more cargo, in ton-miles per year, than a 12-knot ship, but when the length of the voyage was increased to 8000 miles there was little difference in the amount of cargo transported.

Calculations show that with low freights the slower ship is more economical and with high freights the reverse obtains. The modern cargo ship is generally designed for the carriage of cargoes of low specific gravity, but on account of the finer form and often the greater length of machinery space it has been found necessary to seek capacity by fitting a long forecastle. This has the disadvantage of concentrating cargo towards the ends of the ship and so increasing the main longitudinal stresses.

Mr. W. Muckle : Referring to the use of aluminium alloys in ships, I suggest that a saving of 50 per cent in weight is conservative, and that the figure approaches 60 per cent, and the difference will have an appreciable effect on the economics of any such proposition. Good progress has been made in the welding of these materials, and with the lighter weight to be handled a greater degree of prefabrication can be carried out.

Captain J. P. Thomson : We are not making the progress that we should in adopting modern forms of machinery, and with regard to dual-purpose ships few of them exist to-day ; they all went back to their specialised trades.

With regard to the twelve-passenger cargo ship, it has to be taken into account that the accommodation occupies cargo space which will probably cost during the year £1200 in port dues.

The next paper discussed on Thursday morning, April 3rd, was :

CHANGES IN SHIP CONSTRUCTION METHODS, 1850 TO 1950

By Norman M. Hunter

Summary

The early paragraphs discuss briefly the influence of world trade expansion, the introduction of iron and steel and improved equipment. Methods of payment and their effect are considered and then the use of hydraulic power and pneumatic power is mentioned, together with the advent of electric light and power. A section is devoted to early iron and steel working methods and the change to prefabrication by means of templates is noted. Attention is called to changes in machines and a note upon the optical method of marking off is followed by a review of electric welding and its effect upon other shipyard trades. A final paragraph gives some interesting data related to the speed of building.

Discussion

Sir Charles S. Lillicrap : I think that we should have such a review, directing our attention to the technical changes that have taken place, iron, and subsequently steel, replacing wood because of the desire to build larger ships. The use of steel had its setbacks, but improved methods of production soon established it as a reliable material for use in ships. I agree with the author's remarks

on the optical method of marking, and imagine that no one to-day would dispute that the output of ships of all kinds during the war was due entirely to welded construction, where it could be adopted *en masse*.

The welding of ships will go ahead because shortage of steel enforces economy in its use, and welding design and practice mean a considerable saving, and because it will be increasingly difficult to get the labour necessary to do riveting.

A mixture of welding and riveting requires careful consideration. and I would say do not do it at all if you can avoid it. No reference is made to the relative costs of welding and riveting and I would like the author to state his views on this question. I think it is desirable that the matter of the current used, either a.c. or d.c., should be stated definitely and categorically.

Dealing with the speed of building, I would mention a cruiser which was built during the 1914–18 war; the period from the time of laying the keel until the vessel went to sea was ten months, which was a record for a warship of her size.

Mr. F. C. Cocks: The present day shipbuilder is as resourceful as were his forebears and is prepared to make the fullest use of all that science or ingenuity can provide to overcome obstacles to progress. Mechanical aids, while they tend to destroy craftsmanship, have contributed to progress to a degree which would have been impossible without them. Electric welding can be a source of trouble unless exceptional care is exercised and I feel that the piecework payment of welders may constitute a danger. Defective welding is hard to track down and piecework welding should be adopted under strict control of procedure and supervision. Radiographic control has resulted in a conspicuous improvement in workmanship.

Electric welding and large-scale prefabrication have led to wholesale reorganisation of shipyards and often this has only been made possible by the surrender of existing berths. One improvement from the reconstruction of shipyard facilities is the adoption of concreted berths, assembly areas and roadways.

The gunwale is in some ways the most vulnerable point in the structure and is susceptible to the effects of indifferent workmanship or defects in design, so that prudence may recommend a riveted stringer angle in an otherwise wholly welded hull. Many failures have occurred in the welded connection of stringer plate to sheerstrake, and the riveted connection is to be preferred, unless perfection can be guaranteed in the welded connection. Efficient earthing is essential, especially if automatic welding is extensively employed and care must be given to it.

Mr. J. Lenaghan: In shipbuilding, labour relations have changed. We have planning and progress departments and now the foreman must work entirely to the plan and progress charts.

Referring to speed of building, I would mention two examples; working under trying conditions, in 1930–31, a 22,000-ton whale factory ship was put into operation ten months after it was laid down, and in those days not too much was known about whale factory ships, and another ship was built in 1942–43, a time of intense activity, and went to sea nine months after it was laid down.

When ships have been built in such short periods we should do better with the modern equipment of to-day.

Captain J. P. Thomson: I was concerned with the operation of nine drilled or partly drilled ships; one of them was torpedoed twice and drifted for five years before going ashore, which demonstrates the strength of the drilled hull.

On the afternoon of Thursday, April 3rd, the meeting was held jointly with the Institute of Marine Engineers, and the first paper to be presented was:

THE GENERATION OF GAS BUBBLES AT THE SHRINKAGE BOUNDARIES OF BUILT-UP CRANKSHAFTS FOR DIESEL ENGINES

By Shoichi Amari and Eiji Ando

(In the absence of the authors the paper was read by Mr. H. N. Pemberton.)

Summary

Minute bubbles observed generating at the shrinkage boundaries of a built-up crankshaft led to research on this problem, and the results are expressed in three conclusions which are: bubbles occur due to the escape of hydrogen in steel, crankshaft slip is caused by oiliness on the shrink fit surfaces, and bubbles originate independently of slip and do not jeopardise the use of the crankshaft. The data used for the research work and inspection results are given in the paper, in which the generation of bubbles and the cause are discussed, together with questions of the hydrogen content in steel during treatment, the slip at the shrinkage boundary of crankshafts, the frictional coefficients of the shrink-fit surfaces, and the stresses due to shrinkage fit. Following upon the conclusions based upon the researches, the reason is sought for the occurrence of bubbling phenomenon in crankshafts manufactured in Japan and its non-occurrence in those manufactured in Europe.

Discussion

Mr. Glen Thomas: It was thought that the bubbles were associated with defective shrinkage, but, after examining the standard of machining of the contact surfaces, checking the dimensions of the pin diameter and web bore and witnessing the actual shrinkage operation, any doubt was removed.

The phenomenon of gas bubbling at the shrinkage boundaries of built crankshafts has been observed on the Continent and in this country. On a semi-built, eight-throw crankshaft which had been shrunk some three or four months previously, bubbles were discovered on quite a number of the shrinks, and the gas was shown to have a high percentage of hydrogen.

On another shaft, three to four years old, there was no sign of any gas bubbles, which agrees with the Japanese assertion that after about six months it would not be possible to see any gas bubbles.

Sample blocks of steel of Japanese manufacture were sent to this country for examination and analysis; the samples were from different steel works, one from the South and one from the North of Japan, and whereas one analysis did not indicate any abnormal hydrogen content, the other suggested that the original hydrogen content of the steel was high.

It is perhaps significant that the second sample came from the steel works at Muroran, which is connected with the possible influence of atmospheric humidity.

I am satisfied that in the cases which were examined in Japan, in this country and on the Continent, and in which the gas bubbles were found at the shrink boundaries, the shrinkage fits were sound and unaffected by the escape of gas.

I would ask the authors if they are satisfied that the shrinkage failure was due to grease being applied, and exactly how much and what sort of grease was applied.

Dr. S. Livingston Smith: The failure of built-up crankshafts is a subject which B.S.R.A. is dealing with as part of its research programme.

One point cleared up by the experimental work is that the bubbling phenomenon bears no relation to the slip in the built-up crankshaft.

I think the figures given for the coefficient of friction are probably lower than the actual values, because the normal pressure between the mating surfaces has been calculated by assuming an elastic condition, that the assembly is elastic, whereas the values of the permanent set show that the plastic strain is quite appreciable.

The results of tests confirm that the surface finish has little effect on the friction, and that the coefficient of friction is greatest when the mating surfaces are clean and dry. But the application of mineral oil and sperm oil to the pin before assembly gives a coefficient of friction of 0·2 to 0·3, whereas in the shop dry condition it is 0·3 to 0·4.

Since it is not possible to achieve chemically dry surfaces in practice, variation of the friction with the surface condition of the faces is the important thing, and investigations in America seem to confirm that adsorption of hydrogen on the surfaces has little effect on the friction, whereas it seems that the metallic soaps formed by fatty acids are most effective in reducing friction.

One of the main characteristics of cutting fluids is low friction under boundary lubrication conditions; therefore, it would be harmful to shrink fits. The breakdown of shrink fits could arise from additives put into lubricating oil to improve boundary lubricating qualities.

Mr. I. M. Mackenzie: The facts that hydrogen is evolved from steel at ordinary temperatures, and that the rate of evolution is increased when the metal is cold worked, have been known in metallurgical circles for a considerable number of years.

It would be surprising to find that hydrogen came from a shrink fit in Japan and not from a shrink fit in Britain. I doubt if there is any great difference in the quantities of hydrogen being evolved from shrink fits where the shafts are made of basic open-hearth steel. Hydrogen determinations being rather difficult, it is always doubtful whether the results claimed in the two countries are directly comparable. We feel that the hydrogen contents which are determined in basic open-hearth steel in this country are comparable with those reported in the paper, and do not consider a hydrogen content of 6 cubic centimetres per 100 grammes to be abnormally high for the interior of a large forging—the size of which is an important factor in determining the length of time over which the hydrogen is evolved.

We do know that the hydrogen content of steel made in the acid open-hearth furnace is much lower than that made in the basic furnace. Typical values for our acid practice are 3 or 4 cubic centimetres per 100 grammes, whereas for the basic practice they range from 5 cubic centimetres per 100 grammes upwards.

Some of the crankshafts examined in this country may have been made from acid steel, so that in many instances it was not possible to detect the hydrogen evolved from the shrink fits, because it was not coming off fast enough.

Mr. Borrowman: Our interest was aroused by the alarming news that slippage was attributed to the bubbling of shrink fits, since we had the same problem in 1947 concerning a semi-built shaft made in Czechoslovakia. Experienced erectors had noted signs of bubbling, but it was believed that this could not affect the safety of a shrink fit. However, we investigated the matter and found bubbles at different shrinkage boundaries of a semi-built crankshaft which, about three weeks before, had passed official trials. Another shaft of the same size, which

had been in stock for about six months, also showed bubbling, but only to a negligible extent.

It is known that hydrogen enters steel in the atomic state and diffuses out in molecular form, and that in this form it cannot re-enter the steel, but may escape into cavities and eventually build up very high pressures. The question arises whether such hydrogen, trapped between the shrinkage surfaces, could form a film under high pressure which would act against the radial shrinkage pressure. With the finest machining, metallic contact will never cover 100 per cent of the total shrinkage surface, and a net of capillary channels must exist around the higher spots, which have been flattened by stresses above the yield point. The fact that bubbles escape at the shrinkage boundaries made us abandon the idea of a gas film or pockets.

Supersonic tests were carried out on shrinkages, and a considerable variation in the intensity of the echo was noticed; this was not only between webs with or without bubbling, but also over the length of single webs and between different webs showing no signs of bubbling. Tests were made to find out the influence of surface finish and specific pressure, but supersonic control does not give the desired practical results.

Air pockets in shrink fits may exist, especially if the workmanship is not sufficiently accurate or if the pins have been adjusted by filing. Loss in contact in local sections is compensated by higher specific pressure in other sections, so that lack of contact in limited areas does not seriously affect the shrinking moment. Such pockets facilitate the infiltration of oil, and the presence of oil under full working service conditions is dangerous on the coefficient of friction.

A certain portion of the measured values of permanent set, which amount to about 15 per cent of the shrinking allowance of 1·5 to 1·6 per cent of the diameter may be attributed to the flattening of the high spots, but with fine finish a higher allowance would not correspondingly increase the shrinking moment. Sulzer engines with twenty years' service worked successfully with a shrinking allowance of 1·3 to 1·4 per cent; the largest engines, with ten and more years' service, have 1·4 to 1·5 per cent. When calculating the factor of safety we reckon with a friction coefficient of only 0·2, knowing that under normal conditions we actually can rely on 0·3. Experience shows that with a fine dry finish and accurate workmanship our shafts will stand torsional vibration stresses up to ±700kg per square centimetre.

Professor Scott: Work has been done on force fitting of railway wheels and axles, and the effect of the nature of the lubricant was remarkable. With tallow the strength was only a fraction of the strength obtained when using a spindle oil, and it is not a matter of the thickness of the film, but it depends on the nature of the substance separating the metals.

Coming to the result of the radial pressure between the two surfaces in contact, that does not agree with the theory put forward here, if the fit allowance is above a certain value. If the figures can be obtained of the temperature cycle through which the web goes prior to and during shrinking, it would be of help to those who are trying to solve the problem.

Looking at the figures in the table showing the diameters of journal and web bore before shrinking and after dismantling, they give a clear indication that the centre part of the web has been more overstressed than the end part; the assumption of uniform radial pressure on a shrink fit simply does not hold. One explanation is that, when a fit contracts, it not only contracts radially, but also axially, and there will be a higher radial pressure at the centre than at the end.

Dr. S. F. Dorey: It has been brought to our notice that the webs were heated, put into place and then rapidly cooled. We know that if cold air is directed on to a heated web it will contract where it is cooled, and that is on the outside surface, and air is entrapped between the pin and the journal. We have found cases where the shrink is only effective at the outside edges, and no grip is shown in the body of the pin.

There is the important matter of what is at the interface, whether you can get a clean surface and, if you have not a clean surface, whether you can have a lubricant there which will not make much difference. There is a method of shrinking whereby you extend a ring over a pin by means of oil and it closes down, there being grooves at the interface to let out the oil, and it occurred to me that we should fit all propellers to tailshafts by that method. In a fatigue testing machine the specimens are gripped by this method, and it is working under all conditions of stress.

The tests described in the paper, and most of the tests of which results are available, are static tests, the torque applied is not of an alternating character, such as occurs in practice, and I think shipbuilding research will be looking for tests in which alternations of torque can be applied and comparisons made with the static tests.

The paper states that the gas is given out, not only at the interface, but also at other parts of the web, where the metal would be stressed, although not quite so much is evolved there as at the interface. I think the amount of gas evolved will depend on perhaps three factors; first, on whether the material is acid or basic steel; secondly, on the type of stress which is likely to evolve the gas, and thirdly, on the condition of the metal at the time of pouring.

(To be continued)

Krupp-Renn Steel Plant for South Africa

THE formation of a new company, the Dominion Iron and Steel Corporation, the activities of which are now well under way, gives no little promise for the further future development of South Africa as a steel-producing country. This company has been formed for the purpose of production of iron and steel from medium grade ores, by the Krupp-Renn process, and to that end has secured ground at Airlie, near Witbank, in the Transvaal, where large deposits of such ores exist.

It is stated that the ironstone beds at Airlie have the upper band exposed over an area of 60 morgen, and that this undoubtedly extends to the south over a further 300 morgen under a thin cover of Pretoria Series shales. The exposed ore on the edge of the escarpment is said to represent an ore reserve of approximately 18,000,000 tons, with a further 90,000,000 tons under cover to the south. On the remainder of the farm Nooitgedacht, a further 10,000,000 tons are also available in the upper band.

Eight samples over the whole width of the upper band on this farm gave iron contents varying from 44·1 to 57 per cent iron, and averaging 47·6 per cent. The silica content averaged 24·2 per cent. The sulphur content is stated to be negligible and the phosphorus of little significance, and the ore is eminently suitable for the Krupp-Renn process. The silica content is considered sufficient to provide the proportion of slag required for the process, provided that 10 per cent of limestone be added. Confirmation of these statements is said to be contained in the results of tests of the ore and fuel conducted overseas, and in the written opinions of qualified technologists.

The fuel to be used in the Krupp-Renn kiln of the Airlie plant at Witbank will be Witbank duff coal. This is to be dumped by the collieries of that district, less than 80 miles from the Airlie plant, to the extent of more than 1,000,000 tons per annum. The fixed carbon content is more than satisfactory and ranges from about 50 to 59 per cent. This fuel, as duff, is already sufficiently fine, and therefore expenditure on crushing and cleaning plant and on its operation is not involved. It is estimated that delivery to the furnace can be effected at 11s. per ton.

The economic supply of fluxes is one of the important factors in the profitability of the Krupp-Renn process, and it is therefore fortunate that suitable deposits of dolomite—which is a satisfactory flux for the process—occur only 8 miles from the site of the Airlie plant. The deposits are about 800ft thick and are easy to quarry. Delivery to the furnace is estimated to cost about 9s. 2d. per ton.

The original plans of the Corporation included the installation of two Krupp-Renn kilns. However, the world shortage of steel products and the favourable market in the Union caused a modification of these plans. It was accordingly decided to install initially only one kiln and to devote what capital funds would have been expended on the second to the erection of a mild steel plant—turning out reinforcing steel bars, angles, channels, &c. In the present state of the trade market, such products are expected to earn a greater return on the same outlay as would have been involved in the installation of a second kiln. This greater return will obviously permit the accumulation of higher reserves for future expansion.

Another consideration tipping the balance in favour of a steel plant was probably that existing plants turning out finished steel products were, and are, operated to full or nearly full capacity, and also that the position of the Corporation itself would be strengthened by the internal utilisation of its kiln-produced iron nodules or "Luppen," and converting these to pig iron in a Thomas furnace. This pig iron will be treated in the steel plant, consisting of a 200-ton mixer, two 10-ton Bessemer converters, a casting car, reheating furnace, and various mills. The final products from these will be rounds, angles, flats, channels and joists—of a readily marketable range of size.

The Corporation has estimated that the cost of the pig iron delivered to the Bessemer converters will be 48s. 10d. per ton. This figure provides a very satisfactory margin for profitable operations and should enable the Corporation to maintain its position, even with the advent of a buyer's market and the onset of more competitive conditions.

The capacity of the steel plant will initially be about 48,000 tons per annum. This tonnage can be increased to 120,000 tons without major changes to the overall layout of the plant. When the decision is made for this increase, it will involve the installation of a second Krupp-Renn kiln, additional steel-making plant, an extra overhead crane and a ladle car for casting.

Production is planned to commence about the middle of 1953, and the event should mark the start of an important phase in the industrial development of South Africa. The importance, of course, lies mainly in the introduction of such a metallurgical process into South African technique as the Krupp-Renn method. According to all associated with its development, this process is peculiarly adaptable to the treatment of low and medium grade iron ores, with which the country is richly endowed.

The enterprise of the Dominion Iron and Steel Corporation in introducing the Krupp-Renn process into South African industry, and the Corporation's progress, are, therefore, worthy of lively interest.

COLONEL NORMAN BERRY, A.M.I.Mech.E., has taken up an appointment as a principal production officer in the Fighting Vehicle Directorate, Ministry of Supply.

Turbine Gear Hobbing Machines*

In this article, which is based on a communication from David Brown Machine Tools Limited, some notes are given on the development of precision gear hobbing machines at the company's works. The notes include reports of tests made on two turbine gear hobbing machines by the National Physical Laboratory.

THE problem of producing accurately cut gears for high-speed work has exercised the attention of British and American manufacturers of gear-cutting plant ever since the introduction of steam turbines as marine gear main propulsion units.

The exigencies of two world wars stimulated further substantial development in the cutting of such gears and so far as British technique is concerned the ultimate stage was reached in 1948 with the publication of British Standard Specification No. 1498 : 1948, which embodied all previously accumulated experience. This standard was prepared under the authority of the Mechanical Industries Standards Committee at the request of the Admiralty and in close collaboration with that department, the National Physical Laboratory, Lloyd's Register of Shipping and the manufacturers and users of gear hobbing machines for the production of high-grade gears for turbine and similar drives. In addition to Grade "B" requirements for normal production the specification covers a Grade "A" specification applicable to machines designed for the production of relatively heavily loaded gears with high pitch line velocity. It is the Grade "A" specification which is the subject of this article.

David Brown Machine Tools, Ltd., formerly Muir Machine Tools, Ltd., of Manchester, has specialised for many years in the production of both creep and solid table gear-hobbing machines, designed for this standard of work.

There are still two schools of thought on the merits and faults of both kinds of drive and the indications are that the present day limits of accuracy are eliminating the need for creep mechanism, which was originally designed to ensure the distribution of errors which could not be eliminated. In this respect it was undoubtedly successful.

The accuracy of the table drive has been achieved by a process of evolution whereby each master dividing wheel has reduced some of the inaccuracies of its predecessor. The dividing worm wheel in the master machine at the works of David Brown Machine Tools, Ltd., is, in effect, the "great grandfather" of the dividing worm wheels used in practically all turbine gear hobbing machines in existence. However, the accuracy achieved in dividing would not have been of any appreciable value without the parallel development of the precision of the lead screws. The accuracy of the results obtained are shown in the National Physical Laboratory Reports reproduced below.

The third component where the utmost precision is vital is in the dividing worm and these worms are produced for the makers by the David Brown Tool Company at Huddersfield, where full advantage is taken of this associated company's facilities for the accurate production of hobs to the accepted standards laid down by the Admiralty. Ancillary but no less important requisites of production are the conditions under which such master machines work; for example, separate housings in which there is freedom from vibration and fine temperature control.

An important requirement is the maintenance of fine accuracy once it has been achieved. The first necessity is the careful preparation of the large and rigidly designed castings for the machines, which are artificially aged by a stress-relieving heat treatment before machining. Furthermore, the condition of the iron casting after treatment is checked by Brinell testing to ensure homogeneity of the materials on the vital portions, such as slideways, &c.

Another important method of maintaining the required accuracy is that adopted by David Brown Machine Tools, Ltd., on recent machines. These machines (Figs. 1 and 2) have two independent table motions, one of which has a coarse pitch worm wheel, which is used for roughing operations and another with a fine pitch worm wheel for making the finishing cut only. The first machine made to achieve Grade "A" standards of accuracy was supplied to Cammell Laird and Co., Ltd., of Birkenhead, in 1948. This machine, incidentally, had a tandem drive to ensure uninterrupted cutting by the use of one of two alternative sources of power supply, thus providing an automatic changeover in the case of power failure.

The second machine to attain similar limits of accuracy was a 24in pinion machine, which is now installed at the works of the parent company, David Brown and Sons (Huddersfield), Ltd. This machine has certain unusual features, the most noticeable being the combined structure of the head and the work steady, so designed to ensure the utmost rigidity.

To give details of the work necessary to maintain the British Standard Specification requirements the full National Physical Laboratory Specifications on two machines recently

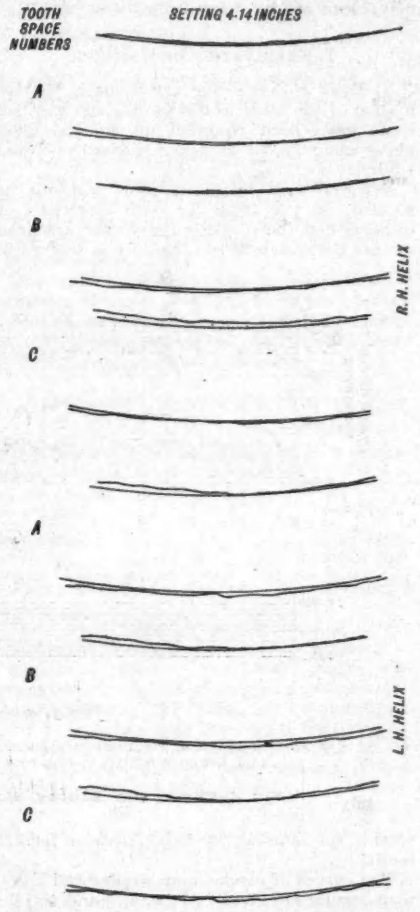


FIG. 3—GEAR TABLE TESTS ON 72IN MACHINE

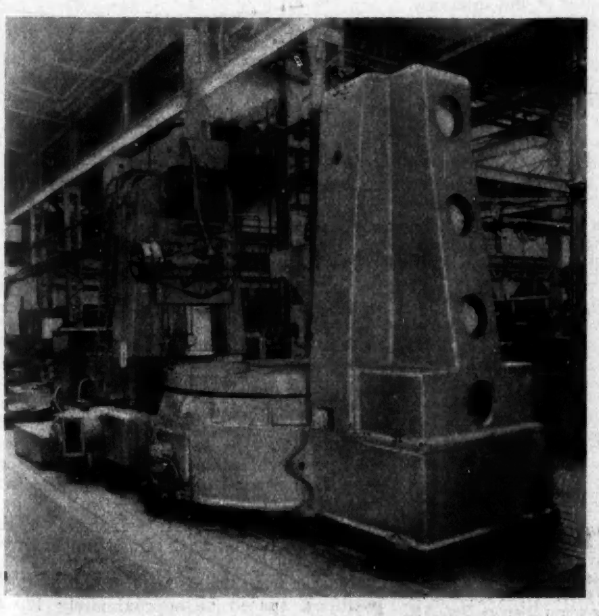


FIG. 1—72IN HOBBING MACHINE

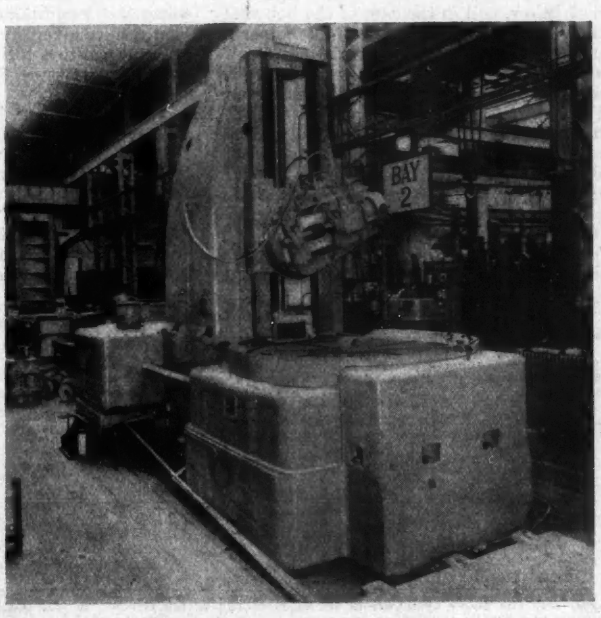


FIG. 2—96IN HOBBING MACHINE

* Communicated by David Brown Machine Tools, Ltd.

built by the company are given below. The first is a 72in machine supplied to W. H. Allen, Sons and Co., Ltd., of Bedford, and the second, a 96in capacity machine supplied to the British Thomson-Houston Company, Ltd., of Rugby.

Report on 72in Wheel-Hobbing Machine and Test Gear

A wheel-hobbing machine for marine turbine gears with solid drive to main table; table diameter 72in.

Worm wheel C.P. 0·3583in; No. of teeth 600; lead of feed screw 0·5in.

I. Examination of Machine

(i) *Table Motion.*—The variations in relative motion of the table to the worm shaft and hob shaft have been recorded on smoked glass plates using the N.P.L. design of Piezo recording equipment.

Records were taken at four positions at 90 deg. on the table for both directions of rotation and the dividing gears were arranged so that the speeds of rotation of hob and worm were in the ratio of 6 to 5, i.e., division for 720 teeth.

The curves of results were similar and specimen results are given in Figs. 4(*a*) and 4(*b*) for clockwise rotation of the table.

The values of the average cyclic error, computed for each position tested, are given in Table I below, and in the case of the hob-shaft records, the average cyclic error of hob-shaft frequency has also been computed.

(ii) *Errors in Hob-Saddle Motion.*—The cyclic errors in relative motion of hob saddle and feed screw were measured at two positions for both directions of feed. The average cyclic error, total range, was found to be within 0·0001in for downward traverse and within 0·0002in for upward traverse of the hob saddle.

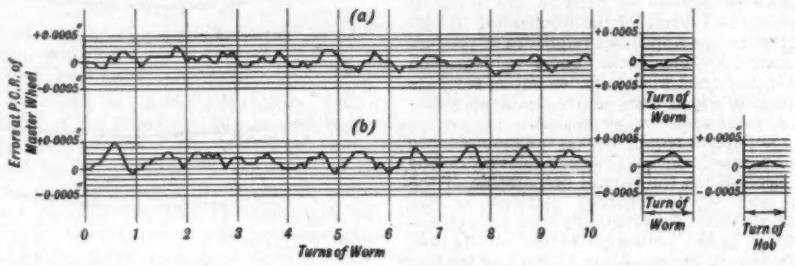
A typical curve of results is shown in Fig. 4(c) for the hob saddle feeding down.

Tests were made to determine the extent of any tilt of the hob saddle in the longitudinal and transverse vertical planes, by means of a sensitive level mounted on the hob saddle. The extent of this tilt, over most of the available traverse of the hob saddle, expressed in terms of relative motion of the hob with respect to the feed-screw nut, does not exceed 0·0003in in the longitudinal plane and is within 0·0002in in the transverse plane.

Table II

Distance of hob-saddle traverse, in	Errors in alignment (Unit 0·0001in)	
	Transverse plane	Longitudinal plane
0	0	0
6	0	−1
12	+0·5	−1
18	+0·5	0
24	0	+1
30	0	+1
36	−1·5	+2
42	−3·0	+3
47	−1·5	+4

Note.—In the transverse plane a "+" sign means that the hob saddle travels towards the right of table axis when facing the machine column. In the longitudinal plane a "+" sign means that the hob saddle travels towards the table axis.



(a) Relative motion of worm to table, clockwise, (b) Relative motion of hob to table, clockwise (c) Errors in relative motion between hob saddle and screw, feeding down.

Fig. 4—Table and Saddle Motion Tests on a 72in Machine

(iii) *Parallelism of Hob-Saddle Motion to Table Axis.*—The parallelism of hob-saddle motion with respect to the axis of rotation of the machine table was measured by means of a test pillar supplied by David Brown Machine Tools, Ltd.

Measurements were made in both the transverse and longitudinal planes at 6in intervals. The results given in Table II show the errors with respect to a position close to the top of the available traverse, for downward traverse of hob saddle.

The errors shown in Table II are within the limits of B.S. 1498 : 1948.

(iv) *Eccentricity of Rotation of Hob Spindle.*—The total indicator variations at three positions along the hob spindle were as given in Table III.

(v) *Axial Float of Hob Spindle.*—The axial float of the hob spindle was found to be 0·0001in for both directions of rotation of the spindle, and therefore complied with specification.

(vi) *Eccentricity of Rotation of Table.*—The total indicator variations at four positions approximately at 90 deg. on a ground reference band on the table periphery were within 0·0010in for both directions of rotation; i.e., satisfactory to specification.

During the course of this test the appropriate radial pressure loading was applied for each direction of rotation.

Table III.—*Eccentricity of Hob Spindle* (*Unit* 0·0001)

Position	On reversing direction of rotation	Maximum permissible error in B.S. 1498: 1948	
		Grade A	Grade B
At drive end	3·0	3·5	2	3
At centre	3·5	4·0	—	—
At other end	3·0	3·0	—	—

II. Examination of Test Gears

(*a*) *Double Helical Gear.*—Tests were made on a double helical gear cut on this machine in respect of tooth flank undulations and axial pitch. Each helix was cut using the same portion of the feed screw. The following are the details of this gear.

Number of teeth	172
Circular pitch	0·58896in
Helix angle	31° 56·87′
Axial pitch	17/16in
Face width	8¼in
Machine feed during finish cutting	0·04in
Hob speed during finish cutting	20 r.p.m.

(i) *Gear Tooth Undulations.*—The calculated wavelengths of typical undulations which may arise from periodic errors in the main machine elements are given in Table IV.

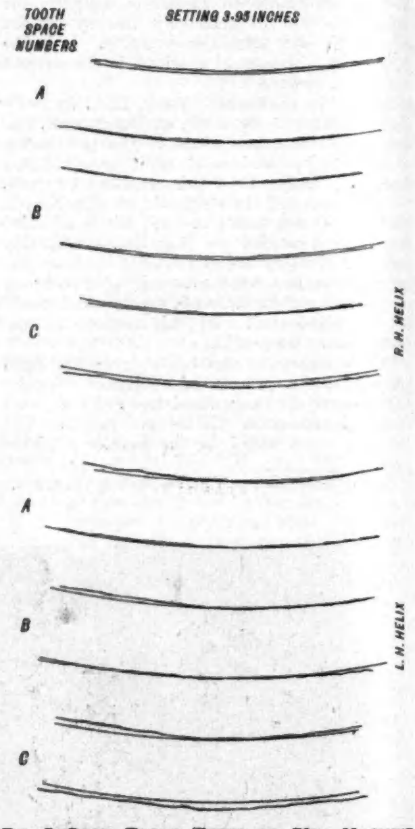


Fig. 5—Gear Table Tests on 72in Machine

In order to establish the amplitude and wavelength of any undulations which may arise from errors in the machine elements given in Table IV, it is essential that the spacing of the two fixed balls of the undulation recorded should correspond to an odd number of wavelengths.

Table V shows the instrument settings, together with the length of instrument traverse in each case.

Records were taken on both helices at three positions, spaced at approximately 120 deg. intervals, round the periphery of the gear.

Table I.—*Cyclic Errors at P.C.R. of Machine Master Wheel.* (*Total range*) *Unit* 0·0001in

Relative motion between	Plate No.	Worm shaft frequency		Hob shaft frequency	
		Clockwise motion	Anti-clockwise motion	Clockwise motion	Anti-clockwise motion
Worm and table	1 (0°)	3·0	2·0	—	—
	2 (90°)	2·5	2·0	—	—
	3 (180°)	2·5	2·0	—	—
	4 (270°)	2·5	1·5	—	—
Hob and table	1 (0°)	2·5	2·0	0·5	1·0
	2 (90°)	3·0	2·5	1·0	0·5
	3 (180°)	3·0	2·5	1·0	0·5
	4 (270°)	3·0	3·0	1·0	1·0

Notes.—(1) The above cyclic errors are satisfactorily within Grade "A" of B.S.1498: 1948. (2) A cyclic error amounting to 0·0003in total range was recorded on each set of flanks of the main indexing worm (Report Ref. MN 154–124).

TABLE IV.—*Gear Tooth Undulations*

Machine element	Number of revolutions per revolution of the machine table	Calculated wavelength along tooth helix (inch)
(a) Periodic error of wormshaft frequency	600 (number of teeth in master wheel)	0·319
(b) Periodic error of feed screw frequency	Lead of feed screw (0·5in)	0·589
(c) Periodic error of 57-tooth gear shaft frequency	$600 \times {}^{49}/_{57} = 515{\cdot}7895$	0·564
(d) Diurnal change in surrounding air temperature	24-hour cycle	7·893

TABLE V.—*Instrument Settings for Various Undulations*

Undulation	Instrument settings (inches)	Instrument traverse (inches)
(a) } Fig. 4	4·14	5
(b) } Fig. 4	4·14	5
(c) } Fig. 5	3·95	5
*(d) } Fig. 5	3·95	5

* *Note.*—This setting is half the diurnal wavelength and consequently the magnification of the diurnal undulation records is only 200.

With the exception of the diurnal waveform, the photographic enlargements in Figs. 3 and 5 represent an overall magnification of 400; i.e. 20×2 mechanical and ×10 optical.

The records show little evidence of any pronounced undulation and the amplitude of the waveform only amounts to 0·0001in.

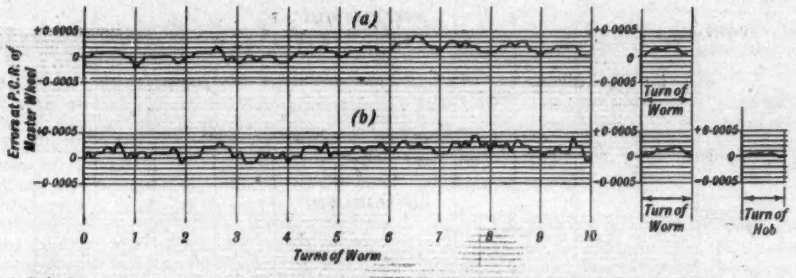
(ii) *Axial Pitch.*—The axial pitch was measured over a length of six pitches of nominal value 5·6667in.

The measured values were found to be:—

R.H. helix ... ... 5·6662in
L.H. helix ... ... 5·6660in

The above errors are satisfactory to Grade "A" limits of B.S.1498 : 1948.

(b) *Double Helical Gear.*—Further measurements of axial pitch were carried out on a double helical gear, which was available at W. H. Allen, Sons and Co., Ltd. The results are given herewith.



(a) Relative motion of worm to table, anti-clockwise. (b) Relative motion of hob to table, anti-clockwise.

FIG. 7—TABLE MOTION TESTS ON A 96IN MACHINE

Gear Details

Circular pitch ... ... 0·45878in
Normal pitch ... ... 0·39984in
Number of teeth 256
Helix angle ... ... 29° 21·89′
Axial pitch ... ... $^{13}/_{65}$in

The axial pitch was measured over a length of seven pitches of nominal value 5·7077in.

The measured values were found to be:

R.H. helix ... ... 5·7072in
L.H. helix ... ... 5·7073in

The above errors are satisfactory to Grade "A" limits of B.S. 1498 : 1948.

This machine is housed in the open shop and there is no provision for precise temperature control.

REPORT ON A 96IN WHEEL-HOBBING MACHINE AND TEST GEAR

A wheel-hobbing machine for marine turbine gears with solid drive to main table; table diameter 96in.

Worm wheel C.P. $\frac{1}{2}$in; No. of teeth 750; Lead of feed screw $\frac{1}{4}$in.

I. EXAMINATION OF MACHINE

Table Motion.—The variations in relative motion of the table to the worm shaft and hob shaft have been recorded on smoked glass plates using the N.P.L. design of piezo recording equipment.

Records were taken at four positions at 90 deg. on the table for both directions of rotation, and the dividing gears were arranged so that the speeds of rotation of the hob and worm were in the ratio of 6 to 5; i.e., division of 900 teeth.

The curves of results were similar and specimen results are given in Figs. 7(*a*) and (*b*) for anticlockwise rotation of the table, showing a cyclic error of worm rotation frequency. The cyclic error is less pronounced in the case of the clockwise records.

The values of the average cyclic errors, computed for each position tested, are given in Table VI and in the case of the hob shaft records, the average cyclic error of hob-shaft frequency has also been computed.

II. EXAMINATION OF DOUBLE HELICAL TEST GEAR

The following are the particulars of a double helical test gear cut on the machine.

Number of teeth 441
Circular pitch ... ... 0·582779in
Axial pitch ... ... $^{24}/_{25}$in
Normal pitch ... ... 0·499747in
Helix angle ... ... 30° 57·623′
Machine feed during finish cutting ... ... $^{1}/_{96}$in
Hob speed during finish cutting ... ... 19 r.p.m.

Tests were made in respect of axial pitch, cumulative pitch and gear tooth undulations.

(i) *Axial Pitch.*—The axial pitch was measured over a length of six pitches, of nominal value 5·8286in. The initial test on the right-hand helix of the gear revealed a variation of 0·0008in between two positions tested at 90 deg. In consequence of this variation, it was decided to recut the R.H. helix.

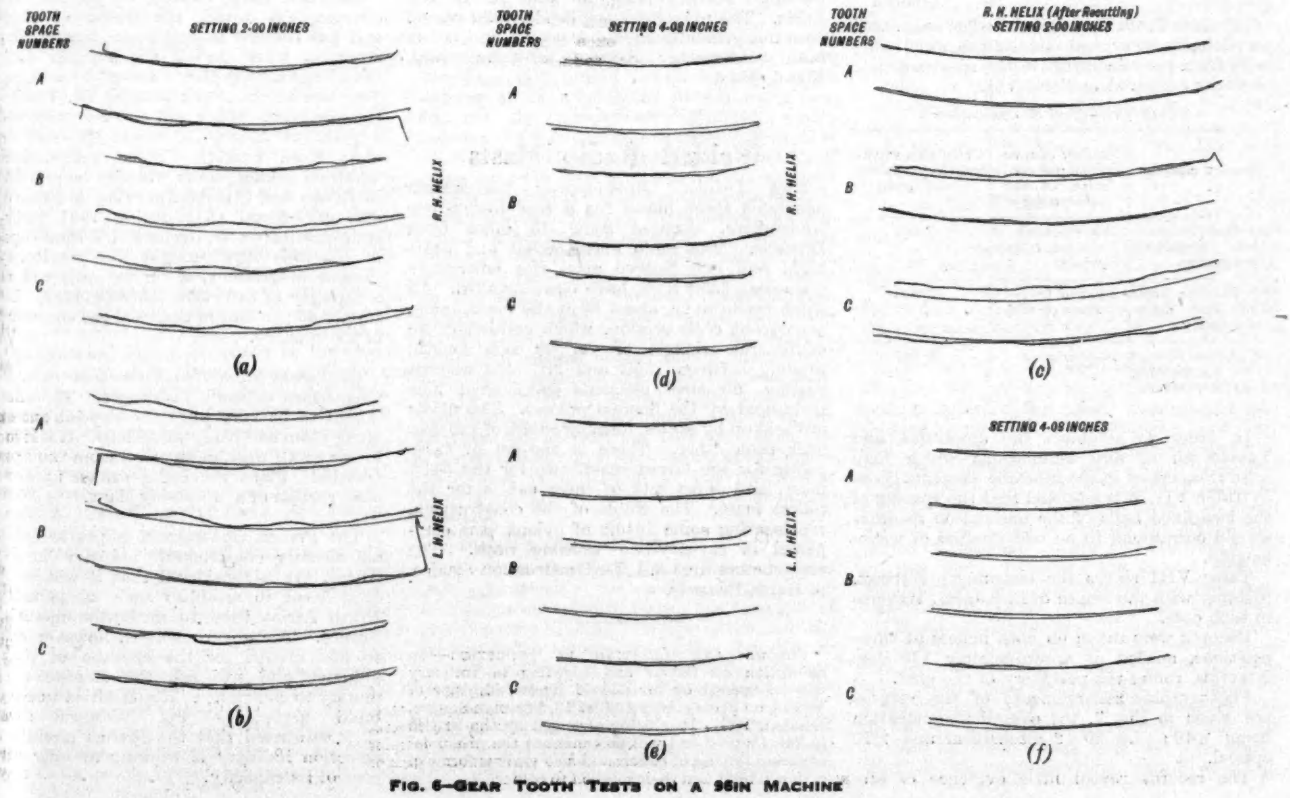


FIG. 6—GEAR TOOTH TESTS ON A 96IN MACHINE

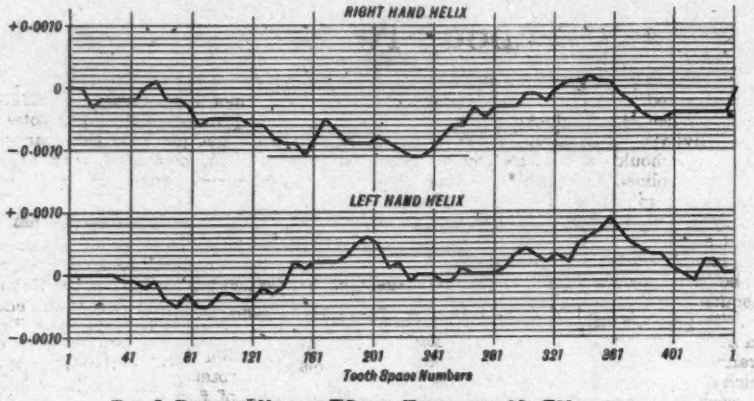


FIG. 8—DOUBLE HELICAL GEAR TESTS ON 96in MACHINE

TABLE VI—*Cyclic Errors at P.C.R. of Machine Master Wheel (Total Range) : Unit* 0·0001in

Relative motion between	Plate No.	Worm shaft frequency		Hob shaft frequency	
		Clockwise motion	Anticlockwise motion	Clockwise motion	Anticlockwise motion
Worm and table	1 (0°)	1·0	1·5	—	—
	2 (90°)	0·5	2·0	—	—
	3 (180°)	1·0	1·5	—	—
	4 (270°)	1·0	2·0	—	—
Hob and table	1 (0°)	1·0	2·0	1·0	0·5
	2 (90°)	1·5	2·0	1·0	0·5
	3 (180°)	1·0	2·0	1·0	0·5
	4 (270°)	1·5	2·0	0·5	0·5

The above elements in Table VI are satisfactory to Grade A, B.S. 1498 : 1948.

The measured values were found to be :—

R.H. helix (first test) ... ... 5·8294in
At 90 deg. ... ... 5·8286in
*L.H. helix ... ... 5·8281in
*R.H. helix (after re-cutting) ... ... 5·8289in

* *Note.*—The above errors are satisfactory to Grade "A" limits of B.S. 1498 : 1948.

(ii) *Cumulative Pitch Errors.*—The cumulative pitch errors of tooth space centre-lines were measured over spans of seven and ten teeth for each helix ; measurements were also repeated on the R.H. helix after recutting. The curves of results are given for spans of seven teeth in Fig. 8 which show the maximum cumulative pitch errors to be :—

R.H. helix ... ... 0·0013in
L.H. helix ... ... 0·0014in

(iii) *Gear Tooth Undulations.*—The calculated wavelengths of typical undulations which may arise from periodic errors in the main machine elements are given in Table VII.

TABLE VII.—*Typical Undulations*

Machine element	Number of revolutions per revolution of the machine table	Calculated wavelength along tooth helix (inch)
(*a*) Periodic error of wormshaft frequency	750 (number of teeth in master wheel)	0·666
(*b*) Periodic error of feed screw frequency	Lead of feed screw (0·5in)	0·583
(*c*) Diurnal change in surrounding air temperature	24-hour cycle	2·067

In order to establish the amplitude and wavelength of any undulations which may arise from errors in the machine elements given in Table VII, it is essential that the spacing of the two fixed balls of the undulation recorder should correspond to an odd number of wavelengths.

Table VIII shows the instrument settings, together with the length of instrument traverse in each case.

Records were taken on both helices at three positions, spaced at approximately 120 deg. intervals, round the periphery of the gear.

Photographic enlargements of the records are given in Fig. 7, the overall magnification being ×40 ; i.e. 20×2 mechanical and ×10 optical.

The records reveal little evidence of any waveform which might be associated with undulations (*a*) or (*b*) of Table VII. Fig. 7 more particularly on the R.H. helix, shows some evidence of an undulation having about three waveforms in the 6in traverse and

TABLE VIII

Undulation	Instrument set-setting (inches)	Instrument traverse (inches)
(*a*) (*c*) Figs. 6*a*, 6*b*, 6*e*	2·00	6
(*b*) Figs. 6*d*, 6*e*, 6*f*	4·08	4

therefore corresponding to item (*c*) of the Table. The maximum amplitude, total range, does not generally exceed 0·0002in and it has been considerably reduced after recutting, Fig. 6(*c*).

Welded Radio Masts

THE Belgian Broadcasting Corporation has built three masts for a new high-power transmitter, situated some 15 miles from Brussels. Two main masts, 804ft and 541ft high, and one reserve mast (for emergency purposes), 295ft high, have been installed. All three masts have, apart from the lowest part, a constant cross section, which consists of an equilateral triangle of various side length, ranging between 10½ft and 9ft. To prevent rusting, all steel elements have been zinc metallised by the Schoop process. The masts are held up by cables, forming angles of 120 deg. with each other. There is one set of three cables for the lowest mast, two for the 541ft mast, and three sets of three cables for the tallest mast. The whole of the construction, representing some 1640ft of pylons, was completed in seventy-two working days. The constructors were S.A. La Construction Soudée, of Haren-Brussels.

COLOUR AND LIGHTING IN INDUSTRY.—An exhibition on Colour and Lighting in Industry will be opened by Mr. David Eccles, Minister of Works, on Friday, May 2nd, at 13, Portman Square, London, W.1. It is being arranged by the British Colour Council and will demonstrate the principles affecting the use of colour and also various forms of artificial light and their relation to colour.

French Engineering News

(By our French Correspondent)

Despite the emotion caused by the disappearance of the village of Tignes beneath the waters of the new reservoir on the Isere (see THE ENGINEER, December 21, 1951), Electricité de France is now planning to build another dam, the lake of which will submerge the picturesque village of Arlempedes. The fate of this village depends on a plan for the production of 325 million kWh by the end of 1953, to achieve which a project known as Montpezat II must be completed. This includes the building of a dam 100m high capable of holding 129 million cubic metres of water. It would be built upstream from Goudet ; the village of Arlempedes is situated within the 470 hectare area of the proposed reservoir.

* * *

The power station at Oudja, Morocco, is to have two further 25 MVA diesel engine sets installed in it. This will bring the production of the plant up to 400 million kWh. The plan evolved by the Sté. Energie Electrique du Maroc includes connecting the Oudja power station to a 150kV network which will link it with the hydro-electric power station at Bin-el-Ouidane. The plant at Oudja will eventually be changed from diesel to steam, first, in order to step up production, and secondly, because the Government would like to see the Moroccan coal mines developed.

* * *

Several interesting machines were exhibited at the twenty-fourth Agricultural Machinery Show which opened in Paris recently. The caterpillar tractor Saint Chamond, built by the Forges et Acieries de la Marine et d'Homécourt, is now being produced in large numbers. At last year's show the prototype was exhibited. It is intended both for agriculture and for road building and public works, and is driven by a four-cylinder Perkins motor developing 40 h.p. at 1800 r.p.m.

The mechanisation of agriculture in France is now a Government policy, which is being actively pursued. Bernard Moteurs exhibited a series of light engines, suitable for installation in a wide range of agricultural machines. The exhibits at the show also included petrol engines from 1 h.p. to 30 h.p. and diesels from 10 h.p. to 120 h.p.

* * *

Gaz de France expects an increase in gas consumption during the winter of 1952–53, and has decided to undertake important construction work during the summer months. Five large coking plants are to be modernised. Two are in the Paris area at St. Denis and Gennevilliers. Work will also be completed on a plant at Alfortville, where the new trunk main from Eastern France will terminate. Work on coking plants will also be carried out in Rouen and Strasbourg. Gaz de France has also announced that during 1951 forty-five supplementary coke ovens with a total capacity of 900 tons were brought into service. The present programme, if carried out, will reach a capacity of 8400 tons daily by 1957. It will supply 45 per cent of the total gas consumption of the country.

* * *

Geologists have found the first substantial magnesium deposits in France. The mineral is said to be very pure, the deposit extending along 150m and being 800m deep. It is situated in the south-west, about 2km from the Spanish frontier. Plans are being drawn up for the construction of a processing plant.

* * *

The French Government hopes to establish an aircraft construction industry in North Africa. It is considered that it will be more economical to establish such an industry in North Africa than to modernise factories in France. The government is, however, unable to find credits for the creation of such an industry and will ask the European Community to contribute. North Africa would then build aeroplanes for Western defence. It is estimated that the French aircraft construction industry is working at only 60 per cent of its capacity.

Industrial and Labour Notes

Employment and Unemployment

The Ministry of Labour has stated that during February the total working population of Great Britain declined by 22,000 and at the end of the month numbered 23,432,000 (16,031,000 men and 7,401,000 women). The number serving in the Forces was 860,000, and in civil employment at the end of February there were 22,158,000 (14,958,000 men and 7,200,000 women), which was 45,000 fewer than at the end of January.

There was a net increase of 1000 during February in the number of people employed in the country's basic industries, the total at the end of the month being 4,078,000. The most important increase in this group of industries was in coal mining, there being an addition of 4000 wage earners to colliery books, bringing the number by the end of the month to 709,000, compared with 698,000 at the end of last year. In the manufacturing industries there was a net decline of 33,000 in the labour forces during February, the most pronounced drop—amounting to 14,000—being in textiles. The Ministry has recently changed its classification of the various sections of the engineering industries. Those grouped under "engineering, metal goods and precision instruments" were employing 2,597,000 at the end of February, indicating an addition during the month of 1000. But in the manufacturing group headed "Vehicles" the number employed at the end of February was 1,074,000, or 1000 less than a month previously. In the "non-manufacturing" industries and services there was a decline of 11,000 in the number employed in the distributive trades, and an addition of 2000 in the labour force of the building and contracting industries. In this latter group there were 1,411,000 people employed at the end of February.

The unemployment figures given in the Ministry's statement show the position on March 17th, when 432,974 people were registered as out of work, compared with 393,480 a month earlier. The March figure represented 2·1 per cent of the estimated total number of employees and included 104,400 described as "temporarily stopped." It also included 136,604 people who had been unemployed for more than eight weeks.

Production Efficiency

On the motion for the adjournment of the House of Commons on Thursday of last week, one of the topics raised concerned production efficiency in industry. The debate was initiated by Mr. Harold Watkinson, who suggested that because of material shortages, including steel, there was a risk of a "defeatist attitude" being adopted by saying that, although the ideal of greater production efficiency was a very desirable one, in the present difficult conditions it was not attainable. Mr. Watkinson went on to say that if restrictive practices by labour and management could be removed, and efficiency and output in the nationalised industries could be increased by a new approach to management and labour relations in those industries, he did not think that the target of 20 to 25 per cent increase in output over three to five years was impossible.

Commenting on the Anglo-American Council on Productivity, Mr. Watkinson said that quite enough productivity teams had been sent to the U.S.A. Every one of them, he claimed, had brought back the same lessons, apart from various technical details which were helpful. The major lesson was that the difference between British and American industry was one, not of plant and equipment, but of the climate of opinion. In America there was the will to produce the maximum at whatever cost, but in this country, he thought, we had not always got that will to-day. Mr. Watkinson said that he was disappointed to find that more had not been done to apply to British industry the lessons learned, particularly the main lesson, that nothing should be allowed to stand in the way of increased output and efficiency in any industry. When the Anglo-American Council on Productivity was wound up, Mr. Watkinson continued, it should be replaced by a small, efficient, streamlined body, which, for the sake of convenience, might be called the Production Efficiency Board. Such a board might be composed of a dozen or so members equally representing management and the trade unions, and might be presided over by the Chancellor of the Exchequer or the President of the Board of Trade. The board's task, Mr. Watkinson added, would be to work through the trade associations to arrange full mutual aid within every industry in which it was desirable that production should be increased. Its functions should also include the nationalised industries.

The Parliamentary Secretary to the Board of Trade, Mr. Henry Strauss, wound up the debate, emphasising that the Government would help and encourage greater productivity, but that it was for both sides of industry to get on with the job. He referred to the fact that the British Standards Institution was engaged upon the revision of all existing standards to secure economy in the use of scarce materials, and to the various ways in which research work was being assisted by the Government. About the Anglo-American Council on Productivity, Mr. Strauss said that it would come to an end as the valuable work which it had been doing in collecting and transmitting the latest American techniques tapered off. It had already been stated that conversations were now in progress between the constituent bodies of the Council to determine whether any purely British body could be set up to take its place and, if so, what should be the constitution and functions of that body. The Government, Mr. Strauss stated, had been informed of the conversations and awaited the final outcome with great interest and a keen desire to help. But the Government would certainly not press, nor would it willingly agree, that the new body should have a Minister in the chair or that it should include members of Parliament. The business of increasing productivity was non-party and non-political, and though the Government could help and encourage, it was for industry to get on with the job.

The Training of Supervisors

In reply to a question in Parliament last week, the Minister of Labour, Sir Walter Monckton, Q.C., stated that during last year the number of firms in Great Britain which had adopted the scheme of "training within industry" for supervisors increased from 2724 to 3008. In addition, a considerable amount of follow-up work had been carried out amongst firms which had previously adopted the scheme. Training within industry, the Minister said, continued to be used in all those industries and services where it had previously been adopted, and there were notable instances of its use to an increasing extent by the National Coal Board, the British Electricity Authority and British Railways. There had also been development to a marked degree among medium and small-sized undertakings. In the course of last year, Sir Walter added, 15,651 supervisors were trained in job instruction, 19,608 in job relations and 6673 in job methods. Since the scheme started eight years ago, 193,095 supervisors had been trained in job instruction, 125,572 in job relations and 37,299 in job methods.

Britain's Overseas Trade

The Board of Trade has announced that, provisionally, the value of United Kingdom goods exported in March has been put at £245,500,000. Taking this figure, the monthly average value for exports in the first quarter was £241,100,000, or 12 per cent higher than the monthly average for 1951. Re-exports in March reached a value of £20,200,000.

Imports in March were valued at £332,800,000 which makes the average monthly value in the first quarter £328,700,000, compared with last year's monthly average of £326,200,000. The excess of imports (c.i.f.) over total exports (f.o.b.) in the first quarter of this year amounted to £212,000,000, compared with an average of £301,900,000 last year.

An Engineering Training Mission

A British engineering training mission, organised by the Federation of British Industries, with the full support of the Government, will leave for Latin America at the end of the month. The mission will consist of Sir Arthur Fleming, chairman of the F.B.I. overseas scholarships committee, and director of research and education of Associated Electrical Industries, Ltd.; Mr. F. R. Livock, education and training manager of the General Electric Company, Ltd., and Mr. W. V. Jenkins, who is responsible for administering the F.B.I. overseas scholarships scheme.

The Federation of British Industries has been developing scholarship projects for overseas engineering graduates over the last twenty years or so. Three years ago it was decided to establish an overseas scholarships scheme, which would include graduates from developing countries, both British and foreign, all over the world. Through the co-operation of British engineering firms, supplemented by a Board of Trade grant, students from Latin America and elsewhere may receive scholarships of a value approaching £1000 each for a two-year course. The contribution from industry consists of a minimum payment of £300 a year for the maintenance of each scholar, plus the administration and provision of the necessary training facilities. The total industrial contribution to the scheme will be about £20,000 a year and the Board of Trade will make a maximum grant of £10,000 for each of the first five years, conditional on a minimum number of scholarships being awarded each year.

The object of the mission to Latin America is to make more widely known the training facilities available in the United Kingdom, to discuss how the scholarships scheme can best be adapted to the needs of Latin American engineering graduates, and to make preliminary arrangements for the selection of suitable candidates. The countries to be visited are Mexico, Cuba, Venezuela, Colombia, Peru, Chile, Argentine, Uruguay and Brazil. The scholarships cover all branches of electrical, mechanical and civil engineering, as well as metallurgy, and are available to graduates from countries in the British Commonwealth and Empire, the Near East, Far East and Africa, in addition to Latin America.

The Coal Situation

Following a meeting of the executive of the National Union of Mineworkers at the end of last week, it was announced that the coal miners had decided to renew the annual agreement to work voluntary week-end shifts. This decision resulted from a ballot among the miners.

Coal output in the week ended April 5th—the last full week prior to Easter—was the highest achieved this year. Deep-mined production amounted to 4,506,900 tons and 223,100 tons were gained from opencast workings, making the week's total 4,730,000 tons. In the first fourteen weeks of this year coal output was 63,247,100 tons, or about 2,500,000 tons higher than in the comparable period of last year. In the first fourteen weeks of last year, however, the Easter holiday reduced output. Coal imports this year have amounted to 318,000 tons. Colliery manpower on March 29th numbered 710,700—compared with 702,800 a year earlier—and of that total 289,900 were working at the face. In the same week inland coal consumption amounted to 4,289,000 tons and exports and bunkers took up 261,000 tons. Total consumption this year to date has been about 2,000,000 tons higher than in the corresponding period of 1951.

Notes and Memoranda

Air and Water

THE LATE MR. S. B. RALSTON.—We regret to record the death of Mr. S. B. Ralston, which occurred last week at his home in Bearsden. Mr. Ralston, who was for thirty years a director and naval architect of Alexander Stephen and Sons, Ltd., of Linthouse, first joined the company in 1896, and invented the ship-stability indicator, which bears his name and which is still widely used.

SAMUEL BAXTER PRIZE.—Under the will of the late Arthur William Baxter, £2000 has been left to the Institution of Naval Architects, and the income is to be used for an annual prize, called the "Samuel Baxter" Prize, for the best contribution towards the safety or efficiency of ships. The award is not confined to members of the Institution, and all papers read before the Institution are eligible for the award.

HOLLOW STEEL BLADE PROPELLERS.—The fleet of twenty-five Bristol "Britannia Type 175" airliners, which are on order for the British Overseas Airways Corporation are to be equipped with de Havilland steel-blade propellers. These propellers, which have long been on test in preparation for this project, are the latest high-efficiency, constant-speed feathering and braking four-bladers having hollow steel blades. In propellers of this size, 16ft in diameter, the hollow steel blade shows a considerable saving in weight over the solid duralumin blade which this company have employed for propellers up to about this size during the past seventeen years. The mechanism of the latest propellers, although highly advanced, is not complicated, and this new model, designated "4/N/6," represents a further stage in the technique of converting shaft power into effective thrust with high aerodynamic efficiency combined with low weight.

TRANSPORT IN THE WESTERN HIGHLANDS.—The Ministry of Transport states that a new contract, which is to run until December 31, 1961, has been made between the Government and David MacBrayne, Ltd., for the maintenance of certain transport services and the carriage of mails in the Western Highlands and Islands of Scotland. The financial arrangements are on similar lines to those of the agreement which the new contract is intended to supersede, the Government paying an annual grant to the company for the maintenance of the specified steamer and road services. The services may be altered from time to time as the Minister of Transport may require. The grant to the company is £360,000 a year, which is estimated to provide the company with a rate of interest on capital employed of 5 per cent, or £35,000 a year, whichever is the greater. This profit is not, however, guaranteed, and, within a limited range, the company may make more or less than that figure according to a formula laid down in the contract. Thus, any profits made over £35,000 are to be shared equally between the company and the Exchequer up to a total of £15,000, from which point the surplus, if any, goes to the Exchequer. Conversely, if the profit falls short of £35,000 the Government will bear one-half of the deficiency only up to a total of £15,000, the other half being borne by the company. The steamer rates and fares charged by the company may be changed only with the consent of the Minister of Transport, but the Minister may require the company to change them. Changes in road fares are subject to existing statutory controls. Provision is made in the contract for the grant to be adjusted if the steamer or road services are altered, if freight rates or fares are changed, or if in two consecutive years the "surplus profits" or deficiency exceed £15,000. The company is required to construct two new ships, one a passenger and mail vessel and the other a cargo vessel.

Miscellanea

TAVAZZANO POWER STATION.—We learn that the first of two 62·5MW generating sets has been commissioned in the methane burning power station at Tavazzano, in Italy. It is stated that the Montecatini Company began work on the station less than two years ago.

THE ORIGINAL ORRERY TO BE EXHIBITED.—We are informed that the original orrery has been lent by the present Earl of Cork and Orrery to the Science Museum, and is being temporarily displayed among the Astronomy Collections. It will be transferred to the Special Exhibition, "The British Clockmaker's Heritage," when that opens in May. Orreries are designed to show the motions of the sun, moon and earth, and to ensure accurate representations of these motions they contain complicated and delicate wheel work. It is therefore not surprising that their construction was undertaken by clockmakers such as Graham and Tompion. The instrument exhibited was made by John Rowley in about 1716 for Charles Boyle, fourth Earl of Orrery, in whose honour these mechanisms now bear their present name of "orrery."

STEEL DELIVERIES FROM U.S.A.—A written Parliamentary reply by Mr. Low, Parliamentary Secretary to the Ministry of Supply, states that, at March 31st, roughly 172,000 long tons of steel, pig iron and scrap for this country had been delivered at United States mills and from other suppliers. Of that quantity, 85,000 tons had arrived in the United Kingdom, and the remaining 87,000 tons were in transit in the U.S.A. and on the sea.

JOINTING OF ALUMINIUM.—We have received from the Aluminium Development Association, 33, Grosvenor Street, London, W.1, a bound volume containing copies of the four papers, two on welding and two on riveting, which were read at the Symposium on Welding and Riveting Larger Aluminium Structures held on November 13, 1951. In addition to the papers, the volume includes the verbal and written contributions to the discussion, together with the authors' replies.

TRACTOR-MOUNTED PUMPS.—Harry Ferguson, Ltd., Coventry, has announced that it has arranged for the manufacture in India of 1000 tractor-mounted irrigation pumps. The contract, which has been placed with the British India Electric Construction Company, provides for the production of 100 pumps a month. The design adopted is a centrifugal pump having a maximum output of 185 gallons a minute at 1975 r.p.m., at which speed it has a head of 70ft and absorbs just over 6 h.p.

INCORPORATED PLANT ENGINEERS.—The fifth annual conference of the Incorporated Plant Engineers is to be held at Harrogate from Wednesday to Friday, May 21st to 23rd. At the annual meeting on Thursday morning, May 22nd, Mr. G. A. Rooley will be installed as president in succession to Mr. D. Lacey-Hulbert. As well as provision for technical discussions, the programme includes a number of social functions for members and their ladies. Mr. H. S. Seaborne, 48, Drury Lane, Solihull, Birmingham, is the general secretary.

SMOKE ABATEMENT.—In a memorandum to the Ridley Committee on National Fuel Policy the National Smoke Abatement Society has urged that full weight be given to the social costs resulting from the use or misuse of fuel, of which the most serious and extensive is that due to smoke. The damage done by smoke and the diversion of labour from production to maintenance that it entails, added to the loss of fuel involved, the Society says, suggests that "smoke prevention may be one of the largest single economies open to the nation."

INSTITUTE OF BRITISH FOUNDRYMEN.—The forty-ninth annual conference of the Institute of British Foundrymen is to be held at Buxton from Tuesday to Friday, June 10th to 13th, the headquarters being at the Spa Hotel. The annual general meeting will be held at 9.15 a.m. on Wednesday morning, June 11th, when Dr. C. J. Dadswell will be installed as president. Following Dr. Dadswell's Presidential Address, which is timed to start at 11 a.m., the Edward Williams Lecture is to be delivered by Professor R. J. Sarjant, of Sheffield University, on the subject of "Fuel and Metal." On Wednesday afternoon and also on Thursday, there are to be technical sessions for the reading and discussion of papers. The Institute's annual banquet is to be held at the Palace Hotel, Buxton, on Wednesday evening, June 11th, and for Friday, June 13th, a series of works visits has been arranged, as well as a luncheon at the City Hall, Sheffield. The local arrangements for the conference are being undertaken by the Sheffield branch of the Institute.

BRITISH CAPACITOR INSTALLATIONS IN CANADA.—The first large capacitor bank to be supplied to Canada by a British manufacturer completed one year's service in September last. This 15,000kVAr, 11kV bank, manufactured by British Insulated Callender's Cables, Ltd., is connected to the system of the Shawinigan Water and Power Company. It is built up from large internally fused tank type units, each with an output of 250kVAr, which represents an innovation in Canadian practice. The units are installed out of doors without weather protection, and are therefore subjected to large seasonal variations in temperature which may range from −40 deg. to 100 deg. Fah. To check the performance of the bank, the capacitance of each unit was recently measured on site, using a capacitance bridge, and it was found that no observable loss of capacitance had occurred during the first twelve months of service in any of the sixty 250kVAr units which make up the bank. A later installation involving a 20,250kVAr, 10kV bank supplied by the same manufacturer to the Aluminum Company of Canada, Ltd., was also tested about the same time, and equally satisfactory results were obtained.

132kV TRANSMISSION LINE FROM FORT AUGUSTUS TO GLENTRUIM.—The North of Scotland Hydro-Electric Board has published the details of a proposed addition to the 132kV Highland grid which will be erected over the 2507ft high Corrieyairick Pass in Inverness-shire. The new transmission line will stretch 25 miles from Fort Augustus to Glentruim, near Newtonmore, where it will join an existing 132kV line from the Tummel Valley to Keith, in Banffshire. At Fort Augustus the new line will connect with lines which will carry the electricity produced by the Affric, Garry and Moriston hydro-electric stations. From a point west of Garva Bridge (a two-arch structure completed in 1732) the Board adjusted the route of the line for a distance of about 7 miles north-westwards to preserve the view and, where possible, to avoid crossing the road. The line will be erected clear of the famous zig-zags in the Pass, and no damage will be done to Wade's bridges during the construction of the line and those which are unfortunately already unfit for use will be by-passed.

Personal and Business

ALVIS, Ltd., Coventry, states that Mr. Alec Issigonis is joining the company on May 1st.

MR. R. M. GRANT, M.I.E.E., has been appointed assistant manager of the plant sales department of the British Thomson-Houston Company, Ltd., Rugby.

MR. F. H. JOHNSON has been appointed a director of Thomas Smith and Sons (Rodley), Ltd., Leeds. He has been a local director of the company for several years.

THE NATIONAL COAL BOARD announces the appointment of Mr. William Smith as deputy chairman of the Scottish Division in place of Dr. William Reid, who became chairman of that division in February.

MR. DAVID K. BUIK has been elected a director of Canadian Pacific Steamships, Ltd. He has been special representative in London of the president of the Canadian Pacific Railway, and in his new appointment his headquarters will continue to be at 62, Trafalgar Square, London, W.C.2.

CAPTAIN (E.) M. LUBY, R.N. (ret.), M.I.Mech.E., F.R.Ae.S., is to join Rotax, Ltd., Willesden Junction, N.W.10, as director and general manager in July. He will also join the board of Joseph Lucas (Gas Turbine Equipment), Ltd., to take responsibility for the co-ordination of the aircraft development work carried out by the parent company, Joseph Lucas (Industries), Ltd.

THE BRITISH BROADCASTING CORPORATION announces the following appointments in its engineering division:—Mr. F. Axon, senior superintendent engineer, external services; Mr. F. Williams, M.I.E.E., senior superintendent engineer, home broadcasting; Mr. H. W. Baker, A.M.I.E.E., superintendent engineer, television studios; Mr. T. H. Bridgwater, M.I.E.E., superintendent engineer, television outside broadcasts; Mr. H. Walker, A.M.I.E.E., head of technical operations, television service; Mr. M. H. Hall, engineer-in-charge, television studios; Mr. W. D. Richardson, engineer-in-charge, television outside broadcasts.

Catalogues

DAVEY, PAXMAN AND CO., Ltd., Colchester.—Publication No. 1269, illustrating the Paxman rotary vacuum filter.

BRITISH JEFFREY DIAMOND, Ltd., Wakefield, Yorks.—Publication illustrating and describing gate belt conveyors.

BRONX ENGINEERING COMPANY, Ltd., Lye, Nr. Stourbridge.—Leaflet dealing with roller levelling machines.

AIR CONTROL INSTALLATIONS, Ltd., Ruislip, Middlesex.—Publication No. R514, entitled "Dust Control by Rotoclone."

NEWTON AND CO., Ltd., 72, Wigmore Street, London, W.1.—Leaflet giving examples from a range of visual aid equipment.

KEITH, BLACKMAN, Ltd., Mill Mead Road, Tottenham, London, N.17.—Booklet giving details of "Tornado" Type dust units.

E. C. HOPKINS, Ltd., Grosvenor Street West, Birmingham, 16.—Catalogue of electric tools and production equipment.

KESTNER EVAPORATOR AND ENGINEERING COMPANY, Ltd., 5, Grosvenor Gardens, Westminster, London, S.W.1.—Leaflet No. 289, describing the Kestner patent automatic gas washer.

British Patent Specifications

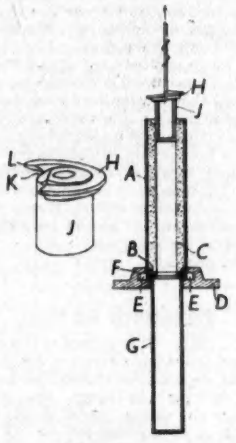
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

CIVIL ENGINEERING

668,023. April 18, 1950.—THE MANUFACTURE OF CONCRETE PIPES, Erven H. Trip's Betonmaatschappij N.V., of No. 79, Oude Gracht, Utrecht, The Netherlands.

The object of the invention is to provide a simple method for producing, in a mould, a pipe from concrete, in such a way that the newly moulded pipe can immediately be released without any artificially accelerated curing being required. The outer form *A* has, near its lower end, an annular pipe end forming pallet *B* for supporting the concrete pipe *C*. The mould rests on a filling platform *D* and lateral projections *E* co-operating with abutments *F* on the platform lock it in position. Immediately after the filling of the mould and removal of the core, the pallet *B* and the pipe resting on it is thrust up out of the form by a ram *G*. The newly moulded pipe, supported by the pallet, can be immediately handled.



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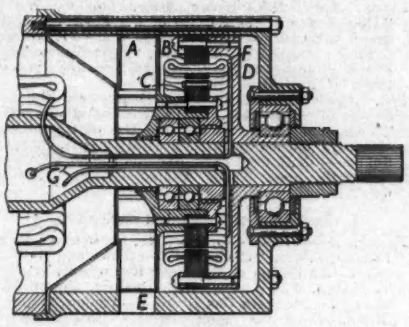
When a fresh pallet is introduced into the outer form the device is ready for another concrete pipe to be produced. The pressing plate *H* and short core *J* has a recess *K*, so that the upper portion of the helice is constituted as a pointed knife *L*. Assuming the core to rest upon the forming pallet, a sufficient amount of concrete having been poured into the mould, some concrete will have fallen on to the pallet through the recess *K*. If the core is now rotated in the direction indicated, more concrete will fall through the recess until the space between the pallet and the helical pressing blade *H* is completely filled. From this moment onward the rotating core screws itself upwards, thereby compressing the concrete below the plate. During rotation concrete continuously falls through the recess to fill up the space below the plate.—*March* 12, 1952.

ELECTRICAL ENGINEERING

666,700. November 4, 1948.—COOLING ARRANGEMENTS FOR ROTATING ELECTRIC MACHINERY, The National Research Development Corporation, of 1, Tilney Street, London, W.1. (*Inventor: Alexander James Martin*).

In the drawing, a ventilating fan *A* is shown driven by an auxiliary squirrel-cage induction motor which is mounted in the same frame as the main machine and comprises primary and secondary members *B* and *C* respectively. The primary member is made up of a number of laminations in the form of a slotted annulus, secured to a spider *D* which is keyed to the rotor shaft of the main machine and rotates with it. The secondary member *C*, which also comprises a series of laminations, is secured to the hub of the fan, which in turn is supported upon ball bearings, through which passes the rotor shaft. In this way the secondary member of the auxiliary motor and the fan are free to rotate independently of the rotor shaft. The air is expelled by the fan through openings in the casing of the rotating machine; one of these openings is indicated at *E*. The supply for the primary windings *F* of the induction motor may be derived from the armature of the main machine by symmetrically placed tappings, or from a separate polyphase winding placed in the same slots as the main armature winding. The connecting wires *G* may be led to the primary windings through a hollow portion of the armature, as shown. The primary



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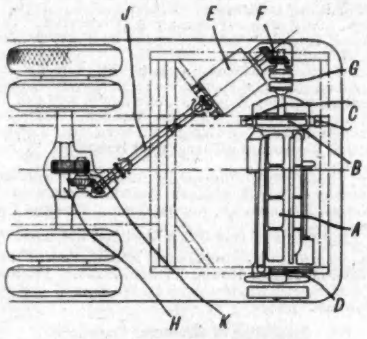
windings of the induction motor are connected so that its rotor revolves in the same direction as the armature of the main machine, and it follows that the motor speed will be equal to the armature speed plus the speed of the induction motor.—*February* 20, 1952.

ROAD TRANSPORT

669,150. October 24, 1949.—DRIVING-MECHANISMS FOR REAR-ENGINED VEHICLES, Aktiebolaget Scania-Vabis, of Sodertalje, Sweden.

The engine *A* is arranged transversely at the rear end of the vehicle and is coupled with the clutch *B*. The engine is held in place by means of rubber supports *C* and *D*. The change-speed gearbox *E* is separately supported in the frame of



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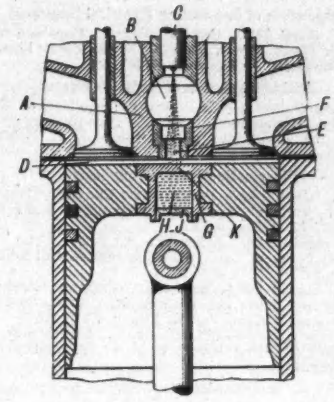
the vehicle and coupled with a bevel gear *F* between the engine and the gearbox. The axis of the gearbox lies at an acute angle in relation to the longitudinal axis of the vehicle. Between the clutch and the bevel gear there is provided a shaft *G* having universal joints, and between the output-shaft of the gearbox and the rear axle *H* there is a shaft *J*, which drives the axle by a bevel gear *K*. —*March* 26, 1952.

INTERNAL COMBUSTION ENGINES

668,893. November 25, 1949.—INTERNAL COMBUSTION ENGINES, Daimler-Benz Aktiengesellschaft, of Stuttgart-Untertürkheim, Germany.

As shown in the drawing, there is provided in a water-cooled cylinder head *A*, beside the inlet and exhaust valves, a precombustion chamber *B*, into which the fuel is injected through a nozzle *C* and which is in communication with the main combustion space *D* through a constricted passage *E* in an insert *F*. A hollow body *G* is inserted or cast in the piston head underneath the precombustion chamber. The hollow body may be provided with upper and lower flanges and made of high grade steel or aluminium alloy. The space *H* in the hollow body is completely or partially filled with a metal such as mercury, or sodium, and closed by a cover *J* pressed or welded in the body. The heat taken up by the head *K* of the insert *G*, which is directly exposed to the fuel issuing from the precombustion chamber, is conducted by the shortest path to the heat-transfer medium in the hollow space. Due to the good thermal conductivity of this medium, the heat is rapidly distributed to the rest of the piston head and by way of the cover to the crankcase air sweeping over the piston head, so that abrupt temperature peaks in the head and resultant dangerous stresses are avoided. This effect, especially with partial filling of the hollow body with the heat-transfer medium, is enhanced by the liquid produced being moved to and fro with considerable force and thereby accelerating the heat transfer. The specification provides for



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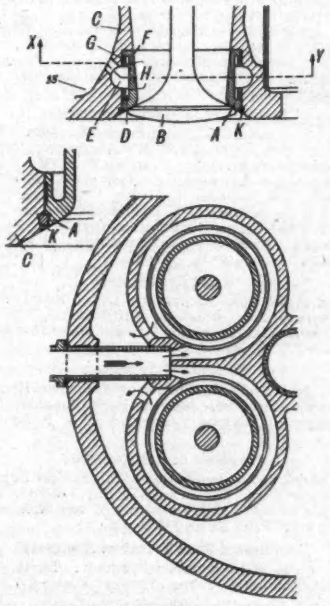
an eccentric arrangement of the precombustion chamber and the provision, on the insertion, of additional ribs for dissipating heat to the crankcase air or to a cooling agent.—*March* 26, 1952.

668,962. March 8, 1950.—INSERTED VALVE SEATS, Sulzer Frères Société Anonyme, of Winterthur, Switzerland.

This invention relates to inserted valve seats for mushroom-type valves. As shown in the drawings, the valve seat *A*, on which seats the mushroom-type valve *B*, is inserted in the cylinder head *C*. The valve seat has an outer annular groove *D*, undercut deeply on both sides, which is in communication with an annular space *E* in the cylinder head around the whole of the circumference of the valve seat. The inner wall *F* of the valve seat is thicker than the parts *G* which adjoin the cylinder



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head and are in the form of flexible skirts provided with sealing surfaces *H* in the valve seat recess of the cylinder head. The valve seat is retained in its place by friction and by a swaged ring *K*, which is shown on a larger scale in the side drawing. In the lower drawing the arrangement of the cooling medium passages is shown in more detail. The cooling medium for the two adjacent valve seats enters through a common inlet pipe, passes into the annular spaces around the valve seats and out into the main cooling spaces of the cylinder head. Modified valve insert arrangements are also shown in the specification.—*March* 26, 1952.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Supervising Electrical Engineers

To-day, April 18th.—CREWE BRANCH: Copeland Arms Hotel, Glebe Street, Stoke, "Motor Fault Locating and Rewinds," D. Bosworth, 7.30 p.m.

British Institution of Radio Engineers

Wed., April 30th.—N.W. SECTION: College of Technology, Manchester, "V.H.F. Broadcasting: The Case for Amplitude Modulation," J. R. Brinkley, 7.15 p.m.

Illuminating Engineering Society

To-day, April 18th.—BIRMINGHAM CENTRE: Imperial Hotel, Temple Street, Birmingham, "Light from Space," W. Wilson, 6 p.m.

Mon., April 21st.—SHEFFIELD CENTRE: The University, Western Bank, Sheffield, Presidential Address, 6.30 p.m.

Thurs., April 24th.—BRADFORD GROUP: Yorkshire Electricity Board, 45–53, Sunbridge Road, Bradford, "Hospital Lighting," J. K. Frisby, 7.30 p.m.

Mon., April 28th.—LEEDS CENTRE: Lighting Service Bureau, 24, Aire Street, Leeds, 1, Annual General Meeting, 7 p.m.

Incorporated Plant Engineers

Thurs., April 24th.—S. YORKSHIRE BRANCH: Grand Hotel, Sheffield, Lecture and Film on the "Manufacture of Wire Ropes," 7.30 p.m.

Fri., April 25th.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, "Incentives," T. Adams, "Administration," J. Lang, 7.30 p.m.

Mon., April 28th.—W. AND E. YORKS BRANCH: The University, Leeds, "How a Technical Knowledge of Timber Can Help a Maintenance Engineer," John Jowett, 7.30 p.m.

Institute of British Foundrymen

Wed., April 30th.—LONDON BRANCH: Waldorf Hotel, Aldwych, W.C.2, Annual General Meeting, "Surface Finish and Facing Sands," F. Roy Pell, 7 p.m.

Institute of Economic Engineering

To-day, April 18th.—The George Hotel, Church Lane, Kingsbury, London, N.W.9, "The F.A.C.T.S. System," J. Philip, 7 p.m.——Engineers' Club, Albert Square, Manchester, "The Measurement of Productivity," P. D. Vincent, 7 p.m.——The Greyhound Hotel, Croydon, "Pre-Production Planning," J. Bailey, 7.30 p.m.

Institute of Fuel

Tues., April 22nd.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, "Recent Developments in Instruments," E. C. Klepp, 5.30 p.m.

Wed., April 23rd.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, Annual Corporate Meeting, 4.30 p.m.; Presidential Address, "Fuel Technology and Civilisation," G. E. Foxwell, 5.30 p.m.

Institute of Industrial Supervisors

Tues., April 22nd.—KIDDERMINSTER SECTION: Carpet Trades, Ltd., Mill Street, Kidderminster, "Current Trends in Supervisory Training," D. H. Bramley, 7.30 p.m.——LEICESTER SECTION: College of Technology, The Newarke, Leicester, "The Cost Department and Supervision," C. E. Power, 7.30 p.m.

Thurs., April 24th.—ROTHERHAM SECTION: Technical College, Rotherham, "American Foremanship Report," W. J. Izzard, 7.30 p.m.

Institute of Metals

To-day, April 18th.—SHEFFIELD LOCAL SECTION: The University, St. George's Square, Sheffield, "Corrosion of Iron and its Prevention by Deposits of Non-Ferrous Metals," U. R. Evans, 6.30 p.m.

Institute of Petroleum

Thurs., April 24th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, Presidential Address, "Kuwait," C. A. P. Southwell, 6 p.m.

Institute of Refrigeration

Tues., April 29th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, "Plastics from the Viewpoint of the Refrigeration Industry," V. E. Yarsley, 5.30 p.m.

Institute of Road Transport Engineers

Mon., April 21st.—SCOTTISH CENTRE: North British Hotel, Edinburgh, Annual General Meeting, 7.30 p.m.

Institution of Chemical Engineers

To-day, April 18th.—LONDON GRADUATES' AND STUDENTS' SECTION: Caxton Hall, Westminster, S.W.1, "The Fluid Catalytic Cracking Process," J. G. Lucas, 6.30 p.m.

Fri., April 25th.—May Fair Hotel, Berkeley Street, London, W.1, Annual General Meeting, 11 a.m.; Annual Dinner, 7 for 7.30 p.m.

Institution of Civil Engineers

Tues., April 22nd.—Great George Street, Westminster, London, S.W.1, "Sewerage and Sewage Disposal in Sub-Tropical Countries," E. J. Hamlin, 5.30 p.m.

Thurs., April 24th.—Great George Street, Westminster, London, S.W.1, "Dowel-Bar Joints for Airfield Pavements," J. A. Loe, 5.30 p.m.

Institution of Electrical Engineers

Tues., April 22nd.—MEASUREMENTS SECTION: Savoy Place, London, W.C.2, "An Analogue Computer for Use in the Design of Servo Systems," E. E. Ward, 5.30 p.m.—SCOTTISH CENTRE: Royal Technical College, Glasgow, "Sound Recording: Home, Professional, Industrial and Scientific Applications," G. F. Dutton, 7 p.m.

Wed., April 23rd.—SUPPLY SECTION: Savoy Place, London, W.C.2, "The Design of High-Voltage High-Power Mercury-Arc Convertors," H. von Bertele, 5.30 p.m.

Thurs., April 24th.—Savoy Place, London, W.C.2, "Iron Atoms in the Service of the Electrical Engineer," Sir Charles Goodeve, 5.30 p.m.——SCOTTISH CENTRE: Music Hall, Aberdeen, "Sound Recording: Home, Professional, Industrial and Scientific Applications," G. F. Dutton, 7 p.m.

Fri., April 25th.—EDUCATION DISCUSSION CIRCLE: Savoy Place, London, W.C.2, Discussion on "The Teaching of Transients and the Use of Operational Methods," opened by D. K. McCleery and H. Tropper, 6 p.m.——N.E. STUDENTS' SECTION: King's College, Newcastle upon Tyne, Annual General Meeting, 6.30 p.m.

Institution of Mechanical Engineers

To-day, April 18th.—Storey's Gate, St. James's Park, London, S.W.1, "Cavitation Mechanics and its relation to the Design of Hydraulic Equipment," Robert T. Knapp, 5.30 p.m.——N.E. BRANCH, GRADUATES' SECTION: Northern Gas Board Showrooms, Grainger Street, Newcastle upon Tyne, "Coal Handling Facilities on the North Bank of the Tyne," G. B. Marriott, 7 p.m.

Sat., April 19th.—E. MIDLANDS BRANCH: Visit to Peterborough Generating Station of the British Electricity Authority, 2 p.m.——The Museum, Priestgate, Peterborough, "Common Errors in Engineering Design and Practice," B. P. Cooper, 4 p.m.——N.W. BRANCH, GRADUATES' SECTION: Engineers' Club, Albert Square, Manchester, Annual General Meeting, "The Pneumatic Handling of Materials," P. W. Rowland, 2.30 p.m.

Mon., April 21st.—MIDLAND BRANCH, GRADUATES' SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, Annual General Meeting, "Clocks and Watches," O. A. G. Wolverson, 7 p.m.——N.W., A.D. CENTRE: Leyland Motors, Ltd., Leyland, "Factors Affecting Operating Costs of Commercial Vehicles," G. J. Waring and F. W. Margetts, 7.15 p.m.

Wed., April 23rd.—WESTERN BRANCH, GRADUATES' SECTION: College of Technology, Unity Street, Bristol, "Some Aspects of Apprenticeship Schemes," A. C. Pritchard, 7 p.m.——N.E., A.D. CENTRE: The University, Leeds, "Shock Absorbers," J. W. Kinchin and C. R. Stock, 7.30 p.m.

Thurs., April 24th.—WESTERN A.D. CENTRE: Royal Hotel, Bristol, "Vehicle Repairs on Factory Lines," H. O. Vaux, 6.45 p.m.

Fri., April 25th.—Storey's Gate, St. James's Park, London, S.W.1, "Explosions in Enclosed Crankcases of Reciprocating Engines," John Lamb, 5.30 p.m.

Sat., April 26th.—YORKSHIRE BRANCH, GRADUATES' SECTION: Technical College, Huddersfield, "Forty-five Years' Experience in Mechanical Handling," J. Ward, 2.30 p.m.

Wed., April 30th.—SOUTHERN BRANCH, GRADUATES' SECTION: Royal Aircraft Establishment Technical College, Farnborough, Annual General Meeting, 7 p.m.

Institution of Post Office Electrical Engineers

Wed., April 23rd.—Conference Room, Fourth Floor, Waterloo Bridge House, London, S.E.1, "Explosives for Increased Production," L. W. Barratt and S. T. Stevens, 5 p.m.

Institution of Structural Engineers

Thurs., April 24th.—11, Upper Belgrave Street, London, S.W.1, "An Investigation of the Behaviour of a Riveted Plate Girder Under Load," S. Mackey and D. M. Brotton, 5.55 p.m.

Junior Institution of Engineers

To-day, April 18th.—39, Victoria Street, London, S.W.1, "Some Modern Submersible Pumping Applications," W. L. Gardiner, followed by a film, 6.30 p.m.

Fri., April 25th.—39, Victoria Street, London, S.W.1, "Condensed Steam Collection: A New System," A. J. Simpson, 6.30 p.m.

Liverpool Metallurgical Society

To-day, April 18th.—Electricity Service Centre, Whitechapel, Liverpool, Annual General Meeting, Presentation of Prize Winning Student Papers, 7 p.m.

North-East Coast Institution of Engineers and Shipbuilders

To-day April 18th.—Mining Institute, Newcastle upon Tyne, "A Study of the Cause of Some Rudder Failures," T. W. Bunyan, 6.15 p.m.

Royal Statistical Society

Thurs., April 24th.—SHEFFIELD GROUP: Grand Hotel, Sheffield, "The Accuracy of the Sampling of Coal," J. Hebden and G. H. Jowett, 6.30 p.m.

Society of Instrument Technology

Tues., April 29th.—Royal Society of Tropical Medicine and Hygiene, Manson House, Portland Place, London, W.1, "Why the Human Operator?" W. E. Hick, 6.30 p.m.

Stephenson Locomotive Society

Mon., April 21st.—MIDLAND AREA: 71, Edmund Street, Birmingham, "Some Interesting Lines in Cumberland," McGowan Gradon, 7.15 p.m.

Sat., April 26th.—Special Train Tour of Potteries District; leave Crewe 2.16 p.m.

Women's Engineering Society

Wed., April 23rd.—MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester, "Transport of Heavy Electrical Plant," A. Mycoe, 6.30 p.m.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

METHODS OF TESTING RAW RUBBER AND UNVULCANISED COMPOUNDED RUBBER: METHODS OF PHYSICAL TESTING

No. 1673, Part 3: 1951. When revising British Standard 902, Methods of Testing Latex, Raw Rubber and Unvulcanised Compounded Rubber, originally published in 1940, it became clearly desirable to issue the revision as a number of separate documents. For this reason a number of standards have been, or will be, issued as separate documents, replacing B.S. 902.

In the standard just issued on methods of testing raw rubber and unvulcanised compounded rubber (methods of physical testing) the methods given are applicable to raw natural rubber and to unvulcanised stocks made therefrom. Reclaimed rubbers and synthetic rubbers are not covered by this standard, though this does not imply that the methods are necessarily unsuitable for these materials.

The major changes made, as compared with B.S. 902, include new methods which have been introduced for the determination of viscosity by the shearing disc viscometer, and the determination of scorching rate of rubber compounds.

The methods retained have been revised and brought up to date, and those described are precision standards of reference, although it is not intended that all the refinements of detail shall necessarily be applied to day-to-day routine testing or in every product specification.

In view of the developments constantly taking place in rubber testing, it is stated that the methods will be kept continually under review in order that they may be brought up to date as occasion arises. The particular forms of apparatus specified have been selected because they are known to give reliable results. Consideration will be given, however, to any proposals submitted to the Institution regarding alternative or improved forms of apparatus. Price 2s. 6d., post free.

PRESSURE GAUGES

No. 1780: 1951. This standard has been drawn up to deal with the wide variety of pressure gauges which are in general use throughout industry and may be bought in large quantities under contract or as single units from engineering suppliers. It is hoped that its use will result in a reduction of the number of types and sizes with consequent benefit to the user in case of replacement and to the manufacturer in the reduction of production difficulties. The standard deals with indicating pressure gauges, vacuum gauges and combined pressure and vacuum gauges of the Bourdon tube type from 2in to 12in nominal size and having maximum scale revisions up to 16,000 lb per square inch or up to 6 tons per square inch.

The specification covers test gauges with concentric scales and industrial gauges with both concentric and eccentric scales. There are eight nominal sizes of gauges with industrial concentric scales and five with eccentric scales, there being also three sizes of test gauge. Direct mounting, surface mounting and flush mounting gauges are covered.

The standard pressure gauges have been carefully selected and the maximum working pressures under steady and fluctuating pressure conditions are given in the same table. Tables are given specifying a large number of dimensions whose purpose it is to standardise, among other things, the fixing sizes, coupling sizes, and dial markings. The graduations are illustrated by charts showing the scales for each pressure range.

Another section of the standard deals with accuracy testing and inspection. There are a number of appendices, of which one deals with testing apparatus and methods, a second deals comprehensively with the installation and use of gauges, and a third gives a detailed explanation of the effect that the acceleration due to gravity may have on gauges manufactured and tested in different parts of the world.
Price 6s. post free.

DIMENSIONS OF CONDUIT DIES

No. 1813: 1951. This publication deals with conduit dies, guides and stocks of the kind used by electrical contractors. Simplified ranges have been standardised with a view to securing the greatest practicable measure of interchangeability. The principal dimensions for three sizes of dies with corresponding guides and stocks are provided, and recommended screwing ranges of B.S. conduit threads for each size of die are given.
Price 2s. post free.